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WEATHER BUREAU

CHARLES F. MARVIN, Chief

BULLETIN

OF THE

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VOLUME 6

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1914

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U. S. DEPARTMENT OF AGRICULTURE

Vol. 6 **BULLETIN** Part I

OF THE

MOUNT WEATHER OBSERVATORY

PREPARED UNDER THE DIRECTION OF THE
ACTING CHIEF U. S. WEATHER BUREAU

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1913

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BULLETIN

OF THE

MOUNT WEATHER OBSERVATORY

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1. VOLCANIC DUST AND OTHER FACTORS IN THE PRODUCTION OF CLIMATIC CHANGES, AND THEIR POSSIBLE RELATION TO ICE AGES.[1]

By W. J. HUMPHREYS.

[Dated June 6, 1913.]

INTRODUCTION.

Old lake beaches, glacial moraines, and various other geological records give indisputable evidence of numerous climatic changes. It appears too that these changes were irregular in their times of occurrence and irregular also in their intensity and duration. Many seem to have been mild and relatively fleeting, while a few were so profound and lasting as even to bring on ice ages and to cover extensive areas of the earth with glacial sheets, or, on the other hand, to melt these sheets away and to establish for long periods warm and genial climates over much the greater portion of the earth.

When this series of climatic changes began there is no sure means of knowing, for the records, especially those of glacial origin, grow gradually fainter and more scanty with increase of geological age, and it is probable therefore that the effects of many of the earlier changes have long since been completely obliterated. But, however this may be, it is well nigh certain that from the time of the earliest known of these changes down to the very present the series has been irregularly continuous, and the end, one might reasonably assume, is not yet. Change after change of climate in an almost endless succession, and even additional ice ages, presumably are still to be experienced, though, except small and fleeting changes to be noted below, when they shall begin, how intense they may be or how long they shall last no one can form the slightest idea.

[1] Developed from a paper presented before the Astronomical and Astrophysical Society of America, at Cleveland, Ohio, Jan. 1, 1913.

Numerous attempts, some of them invoking purely terrestrial and others extraterrestrial or cosmical conditions, have been made to find a probable and at the same time an adequate physical basis for or cause of the known climatic changes of the distant past, and especially for those profound climatic changes that brought about the extensive glaciation that prevailed during the so-called ice ages; but nearly all the older suggestions have been definitely and finally abandoned, either because of inconsistency with known physical laws or abandoned because they are inadequate to meet the conditions imposed upon them by the results of geological investigations.

FACTS OF CLIMATIC CHANGES.

Among the more important geological conditions, with respect to climatic change, that appear to have been established and presumably, therefore, must be met by any theory that would account for such changes or explain specifically the origin of ice ages are the following:

(*a*) The climatic changes were several, probably many.

(*b*) They were simultaneous over the entire earth, and in the same sense; that is, colder everywhere at the same time (climatically speaking) or warmer everywhere.

(*c*) They were of unequal intensity.

(*d*) They probably were of irregular occurrence and of unequal duration.

(*e*) They, at least one or more, progressed with secondary variations of intensity or with advances and retreats of the glacial edge.

(*f*) They have occurred from very early, probably from the earliest, geological ages down to the present, and presumably will continue irregularly to recur for many ages yet to come.

PRINCIPAL ICE-AGE THEORIES.

It would be easy to catalogue perhaps a score of more or less rational hypotheses in regard to the origin of the ice ages, and doubtless even a larger number that are quite too absurd ever to have received serious consideration, and to point out in each case the known and the suspected elements of weakness. But this would only be a repetition of what, in part at least, has often been done before and therefore could serve no good purpose.

As already stated, only a few of these hypotheses still survive, nor do all of even these few really merit the following they have. Apparently those which still claim each a large number of adherents are, respectively:

(*a*) *Croll's eccentricity theory.*[1]—This is based on the assumption that when the earth's orbit is most eccentric or when the earth's

[1] Phil. Mag. 28, p. 121, 1864, and elsewhere.

maximum solar distance differs most from its minimum solar distance, ice will accumulate to a greater extent over that half of the globe which has its winter during aphelion.

For some time Croll's theory was very generally accepted, and it seems still to have many adherents despite the destructive criticisms of Newcomb [1] and Culverwell.[2]

The chief objections to Croll's theory are:

1. That the assumption that midwinter and midsummer temperatures are directly proportional to the sun's heat at these times is not at all in accord with observed facts.

2. That each ice age would be limited to a fraction of the precessional period, 21,000 years, which, according to most geologists, is too short a time. In fact it is already longer than this whole period, according to the best evidence, since the culmination of the last ice age.

3. That the successive ice ages would have occurred *alternately* in the Northern and the Southern hemispheres instead of, as is generally believed to have been the case, in both hemispheres *simultaneously*.

(*b*) *The carbon dioxide theory.*—This theory, advanced by Tyndall,[3] Arrhenius,[4] Chamberlain,[5] and others, is based on the selective absorption of carbon dioxide for radiation of different wave lengths and on its assumed variation in amount.

It is true that carbon dioxide is more absorptive of terrestrial than of solar radiations and that it therefore produces a greenhouse or blanketing effect, and it is also probably true that its amount in the atmosphere has varied through appreciable ranges as a result of volcanic additions on the one hand and of oceanic absorption and chemical combination on the other. But it is not possible to say exactly how great an effect a given change in the amount of carbon dioxide in the atmosphere would have on the temperature of the earth. However, by bringing a number of known facts to bear on the subject it seems possible to reach approximate conclusions. Thus from the experiments of Schlaefer[6] we know that at atmospheric pressure a column of carbon dioxide 50 centimeters long is ample for maximum absorption, since one of this length absorbs quite as completely as does a column 200 centimeters long at the same density. Also from the experiments of Ångström [7] and from those of E. v. Bahr [8] we know that the absorption of radiation by carbon dioxide or other gas increases with increase of pressure and, what

[1] Amer. Jr. Sci. 11, p. 263, 1876; Phil. Mag. 17, p. 142, 1884.
[2] Phil. Mag. 38, p. 541, 1894.
[3] Phil. Mag. 41, p. 237, 1896.
[4] Phil. Mag. 22, p. 277, 1861.
[5] Jr. Geol. 7, p. 752, 1899.
[6] Ann. der Phys., v. 16, p. 93, 1905.
[7] Arkiv för Matematik, Astronomi och Fysik, v. 4, No. 30, 1908.
[8] Ann. der Phys., v. 29, p. 780, 1909.

is of great importance, that both qualitatively and quantitatively this increase of absorption is exactly the same whether the given higher pressure be obtained by compression or by the addition of an inert gas.

Now the amount of carbon dioxide in the atmosphere is equivalent to a column of the pure gas at ordinary room temperature and atmospheric pressure of roughly 250 centimeters in length. Hence, according to the experiments just described of Ångström and E. v. Bahr, the carbon dioxide now in the atmosphere must absorb radiation very approximately as would a column 475 centimeters long of the pure gas at its average barometric pressure of, say, 400 mm. But Schlaefer's experiments above referred to show that such a column would be just as effective as one two or three times this length, and, on the other hand, no more effective than a column one-half or one-fourth as long.

Hence, finally, doubling or halving the amount of carbon dioxide now in the atmosphere, since this would make but little difference in the total pressure, would not appreciably affect the amount of radiation actually absorbed by it, whether of terrestrial or of solar origin.

Again, as already explained by Abbot and Fowle,[1] the water vapor always present in the atmosphere leaves, because of its high coefficients of absorption in substantially the same regions where carbon dioxide is effective, but little radiation for the latter to take up. Hence for this reason, too, as well as for the one given above, either doubling or halving the present amount of carbon dioxide could alter but little the total amount of radiation actually absorbed by the atmosphere, and therefore, seemingly, could not appreciably change the average temperature of the earth or be at all effective in the production of marked climatic changes.

Nevertheless, in spite of both the above objections, there appears to be at least one way by which a change, especially if a decrease, in the amount of carbon dioxide in the atmosphere might affect temperatures at the surface of the earth, so that we are not yet in position to say that no such change was ever an appreciable factor in the production of an ice age.

Further discussion of this particular point will be taken up later, after the introduction of certain observational evidence that seems to bear on the subject.

We will now return to the existing ice-age theories and consider briefly just two more before coming to the main body of the paper.

(c) *The solar variation theory.*—This is based on the assumption that the solar radiation has waxed and waned, either cyclically or irregularly, through considerable ranges and over long intervals of time.

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[1] Annals of the Astrophysical Observatory, Smithsonian Institution, v. 2, p. 172, 1908.

This theory is seductively attractive; it looks so simple, so sufficient, and so safe from attack. But if impossible to disprove, it is equally difficult to establish, and therefore it should conditionally be put aside, held in reserve as it were as a last resort, in favor of a more complete search for and examination of other possible causes, for after all the supposed solar changes, for which we can assign no probable cause or causes, may never have happened.

(*d*) *The elevation theory*.—This theory assumes the simultaneous (geologically speaking) rise or fall of many, possibly all, land areas through a range that may have amounted to several thousand feet. It is argued that such movements would account for not only the phenomena of the ice ages, but also for, among other things, the many suboceanic canyons, such as that of the Hudson, the St. Lawrence, the Kongo, and others.

This theory is mentioned here, not because of the number of supporters it has at present, for obviously this number is not large, but because any such changes in elevation that it supposes, whether local or general, if they ever took place, and apparently great changes in elevation have occurred, must have affected the climates of the regions that so moved, and therefore must have been a factor—no one knows how great—in the production of at least regional, if not world-wide, climatic changes of the past.

These three theories then, omitting (*d*) which but few support, of the origin of the ice ages, namely: The eccentricity theory, the carbon dioxide theory, and the solar variation theory, are the only ones that at present appear to have many adherents, and even these few seem more likely to lose than to gain in number and strength of defenders. The first has failed utterly under searching criticism; the second has been sadly impaired; while the third, provokingly secure from all tests, is strong only as, and to the extent that, other theories are disproved or shown to be improbable.

The above introduction brings us to the essential purpose of this paper, to the discussion of a factor in the production of climatic changes, including, possibly, even those great changes incident to the advance and retreat to maximum and minimum of glaciation. It may not have been the chief cause of our greatest climatic changes or even a large contributing factor, but nevertheless a factor, possibly of large size, and therefore worthy of consideration.

The factor in question is—

VOLCANIC DUST IN THE UPPER ATMOSPHERE.

After the outline of the following discussion had taken shape it was found, on looking up the appropriate literature, that the cousins P. and F. Sarasin [1] had suggested a number of years ago that the low

[1] Verhandlungen der Naturforschenden Gesellschaft in Basel, vol. 13, p. 603, 1901.

temperature essential to the glaciation of ice ages was caused by the absorption of solar radiation by high volcanic dust clouds.

But the idea that dust of this nature when scattered through the atmosphere may lower the temperature of the surface of the earth was already old, having been advanced at a much earlier date, in fact long before even the existence of ice ages had been suspected, much less attempts made to find their cause. Thus, in May, 1784, Benjamin Franklin (and he may not have been the first) wrote as follows:

> During several of the summer months of the year 1783, when the effects of the sun's rays to heat the earth in these northern regions should have been the greatest, there existed a constant fog over all Europe and great part of North America. This fog was of a permanent nature; it was dry, and the rays of the sun seemed to have little effect toward dissipating it, as they easily do a moist fog arising from water. They were, indeed, rendered so faint in passing through it that, when collected in the focus of a burning glass, they would scarcely kindle brown paper. Of course, their summer effect in heating the earth was exceedingly diminished.
>
> Hence the surface was early frozen.
>
> Hence the first snows remained on it unmelted, and received continual additions.
>
> Hence perhaps the winter of 1783–84 was more severe than any that happened for many years.
>
> The cause of this universal fog is not yet ascertained. Whether it was adventitious to this earth, and merely a smoke proceeding from the consumption by fire of some of those great burning balls or globes which we happen to meet with in our course round the sun, and which are sometimes seen to kindle and be destroyed in passing our atmosphere, and whose smoke might be attracted and retained by our earth; or whether it was the vast quantity of smoke, long continuing to issue during the summer from Hecla, in Iceland, and that other volcano which arose out of the sea near that island, which smoke might be spread by various winds over the northern part of the world is yet uncertain.
>
> It seems, however, worth the inquiry, whether other hard winters, recorded in history, were preceded by similar permanent and widely extended summer fogs. Because, if found to be so, men might from such fogs conjecture the probability of a succeeding hard winter, and of the damage to be expected by the breaking up of frozen rivers in the spring; and take such measures as are possible and practicable to secure themselves and effects from the mischiefs that attend the last.[1]

The idea, then, that volcanic dust may be an important factor in the production of climatic changes is not new, though just how it can be so apparently has not been explained, nor has the idea been specifically supported by direct observations. This is not to be taken as a criticism of the above-mentioned pioneer paper by the cousins Sarasin, for indeed the arguments, now easy, were at that time impossible because the observations upon which they largely are based had not then been made. Indeed the *absorption* of radiation by volcanic dust, by which they supposed the earth's temperature to be lowered, can now be shown to be of itself alone not only insufficient, but even productive, in all probability, of the opposite effect—of a warming instead of a cooling of the earth's surface.

---

[1] See Sparks, "Life of Benjamin Franklin," vol. 6, 455–457. (Cited by Abbe in Proceedings of the Amer. Phil. Soc., vol. 45, p. 127, 1906.)

To make this point clear: Consider a thin shell of dust about the earth and let I be the average intensity of the normal component of solar radiation on it. Further, let a be the "dust coefficient" of absorption for solar radiation, independent, presumably, of intensity, and b "the dust coefficient" of absorption for earth radiation. Obviously, in the case of equilibrium, all the energy absorbed by the dust is radiated away, half of it, very approximately, to the earth and half of it to space. Hence, starting with I as the solar radiation normally incident, per unit area and unit time, upon the dust layer, we have, if there is no reflection and no scattering,

aI = rate of absorption of solar radiation,

$I(1-a)$ = intensity of solar radiation reaching earth, or lower atmosphere,

$\frac{aI}{2}$ = intensity of dust radiation, resulting from above absorption, reaching earth.

Summing these two radiations incident upon the earth we have

$$I(1-a)+\frac{aI}{2}=I(1-\frac{a}{2}).$$

Eventually, when equilibrium is established, the earth must lose the same amount of radiation that it gains, though of course chiefly through a different spectral region, and therefore, after a time, assuming the earth to absorb all incident radiation.

$I(1-\frac{a}{2})$ = the intensity of the outgoing as well as that of the incoming radiation.

Of this the dust absorbs, per unit area and unit time, $bI(1-\frac{a}{2})$, of which, in turn, one-half is radiated to space and one-half back to the earth, there to be reabsorbed and again radiated. The intensity of the normal radiation now reaching the earth is

$$I(1-\frac{a}{2})+\frac{b}{2}I(1-\frac{a}{2}),$$

of which the second term becomes, after a time, the increase in the intensity of the outgoing radiation. Hence, after further absorption and reradiation by the dust layer, the next increment of radiation to the earth is $(\frac{b}{2})^2I(1-\frac{a}{2})$, and so on indefinitely.

In the end, then, when the ultimate equilibrium is reached, the intensity of the total normal radiation reaching the earth, I_e, is given by the equation,

$$I_e=I(1-\frac{a}{2})\left\{1+\frac{b}{2}+(\frac{b}{2})^2+\ldots+(\frac{b}{2})^{\infty}\right\}$$

$$\text{or } I_e=I\left\{1+k(b-a)\right\}\ldots\ldots\ldots\ldots(A).$$

in which

$$k=\frac{1}{2}\left\{1+\frac{b}{2}+(\frac{b}{2})^2+\ldots\ldots+(\frac{b}{2})^{\infty}\right\}$$

Now b is positive, and therefore k is also positive. Hence

$$I\left\{1+k(b-a)\right\}\begin{matrix}>\\=\\<\end{matrix}I, \text{ according as } b\begin{matrix}>\\=\\<\end{matrix}a.$$

That is to say, the total amount of radiation reaching the earth is increased, unchanged, or decreased by the surrounding dust layer according as the dust's coefficient of absorption of terrestrial radiation is greater than, equal to, or less than its coefficient of absorption of solar radiation.

Now in the case of many, if not all, rocky materials, such as make up the particles of volcanic dust, the coefficient of absorption is much greater for terrestrial radiation than for solar radiation,[1] or, in terms of the above symbols, in the case of volcanic dust b is greater than a. Hence, so far as mere absorption of radiation is concerned, the only action mentioned by the cousins Sarasin, a veil of volcanic dust in all probability would slightly *increase* and not decrease, as they supposed, the average temperature of the earth.

But then absorption is not the only effect of a dust veil on radiation; reflection and scattering both are important and must be fully considered.

These actions, however, reflection and scattering, depend fundamentally upon the ratio of the linear dimensions of the particles concerned to the wave length of the incident radiation, and therefore before undertaking to discuss them in this connection it will be essential to determine the approximate size of the individual grains of floating volcanic dust, and also the average wave length, weighted according to energy, of solar and of terrestrial radiation. It will be desirable also to consider whether or not, and if so how, dust of any kind can remain long suspended in the atmosphere. And this point will be examined first, since, obviously, the longer the dust can float the more important, climatically, it may have been in the past and in the future may again become.

Atmospheric regions.—The atmosphere is divisible into the stratosphere and the troposphere; or the isothermal region and the convective region; or, in other words, the region, in middle latitudes, at and beyond about 11 kilometers above sea level where, being free from vertical convection, ordinary clouds never form and the turbulent, stormy region below this level frequently swept by clouds and washed by snow and rain. The physical reason for or cause of the existence of the isothermal region is well known [2] and is such that we feel quite sure that ever since the earth was warmed by solar radiation, as at present, rather than by internal heat, the temperature of its atmosphere beyond a certain level, whatever its composition, must have varied but little, as it now varies

[1] Coblentz, Publications of Carnegie Institution of Washington, Nos. 65 and 97.
[2] Humphreys, Astrophys. Jr. 29, p. 14, 1909. Gold. Proc. Roy. Soc. Series A. 82, p. 43, 1909.

but little, with change of altitude, and therefore that this region must then have been free as it now is free from clouds and condensation. Obviously, then, in the past, as in the present, and as it must continue to be so long as the earth shall have an atmosphere, any volcanic or other dust, that by whatever process was gotten into and distributed through the isothermal region where there were no clouds or other condensation to wash it out, must have drifted about till gravity, overcoming the viscosity of the atmosphere, by slow degrees pulled it down to the region of clouds and storms. How long such a process must take depends of course upon a number of things, among which the size of the particles is vitally important. And this brings us to the next consideration.

Size of volcanic dust particles.—For two or three years after the eruption of Krakatoa in 1883, also after the eruption of Mount Pelée and Santa Maria in 1902, and again after the eruption of Katmai in 1912 a sort of reddish brown corona was often, under favorable conditions, observed around the sun. It was 10° to 12° wide and had an angular radius, to the outer edge, of 22° to 23°. This phenomenon, known as Bishop's ring, clearly was a result of diffraction of sunlight by the particles of volcanic dust in the upper atmosphere, and therefore furnished a satisfactory means for determining the appropriate size of the particles themselves. This subject has been rather fully discussed by Pernter,[1] who finds the diameter of the particles, assuming them spherical, to be approximately 185×10^{-6} cm., or 1.85 microns. The equation used has the form

$$r=\frac{m}{\pi}\frac{\lambda}{\operatorname{Sin}\theta}$$

in which r is the radius of the dust particle, λ the wave length of the diffracted light (here taken as 571×10^{-7} cm., or 0.571 micron), θ the angular radius of the ring and m a numerical term which for the outer edge of the ring and successive minima has the approximate values, $\frac{\pi}{2}(n+0.22)$, in which $n=1,2,3$, respectively.

Now since the width and angular dimensions of Bishop's ring, as seen at different times and under different circumstances, have varied but little, the above value, 1.85 microns, may provisionally be assumed to be the average diameter of those particles of volcanic dust that remain long suspended in the atmosphere.

Time of fall.—The steady or terminal velocity of a sphere falling in a fluid, assuming no slip between fluid and sphere, is given by Stokes'[2] equation

$$V=\tfrac{2}{9}\,gr^2\frac{(\sigma-\rho)}{\mu}$$

[1] Met. Zeit. 6, p. 401, 1889.
[2] Math. and Phys. Papers, Vol. 3, p. 59.

in which V is the velocity of the fall, g the acceleration of gravity, r the radius of the sphere, σ the density of the sphere, ρ the density of the fluid, and μ its viscosity.

However, there always is slip, so that the actual velocity of fall is, according to Cunningham,[1]

$$V=\tfrac{2}{9}g\,r^2\frac{(\sigma-\rho)}{\mu}\left(1+A\frac{l}{r}\right)$$

in which l is the free path of the gas molecules, A a constant, and the other symbols as above explained.

Obviously l, other things being equal, is inversely proportional to the gas density, or pressure, if temperature is constant. Hence

$$V=\tfrac{2}{9}\,g\,r^2\frac{(\sigma-\rho)}{\mu}\left(1+\frac{B}{rp}\right) \qquad (1)$$

in which B is a constant for any given temperature, p the gas pressure, or, if preferred, barometric height.

Now, a series of valuable experiments by McKeehan[2] has shown that for 21° C. and when p is the pressure in terms of millimeters of mercury,

$$B=0.0075\pm3.$$

The value of μ, for dry air, is also closely known from the careful work of Breiterbach,[3] Schultze,[4] Fischer,[5] and others, all of whom obtained nearly the same values. At the absolute temperature T, as computed by Millikan[6] from results obtained by these observers,

$$\mu_T=\frac{150.38\,T^{\frac{3}{2}}}{T+124}\times10^{-7}.$$

Therefore it is easy to compute, by the aid of equation (1), the velocity of fall of volcanic dust, assuming gravity to be the only driving force. There is, of course, radiation pressure, both toward and from the earth, as well as slight convective and other disturbances, but presumably gravitation exerts the controlling influence, and hence it alone will be considered.

The following table of approximate velocities and times of fall for volcanic dust was computed by substituting in equation (1) the given numerical values, namely:

$g=981\,\frac{\text{cm.}}{\text{sec.}}$

$r=0.000092$ cm.

$\sigma=2.3$, approximate density of Krakatoa dust.

$\rho=0$, being negligible relative to σ.

$\mu=1416\times10^{-7}$, appropriate to $-55°$ C., roughly the temperature, in middle latitudes, of the isothermal region.

$B=0.0056$, appropriate to $-55°$ C.

$p=$ millimeters barometric pressure.

[1] Proc. Roy. Soc. 83 A, p. 357, 1910.
[2] Phys. Rev. 33, p. 153, 1911.
[3] Ann. der Phys. 5, p. 168, 1901.
[4] Ann. der Phys. 5, p. 557, 1901.
[5] Phys. Rev. 28, p. 104, 1909.
[6] Ann. der Phys. 9, p. 759, 1913.

Velocity and time of fall.

Height in kilometers.	Barometric pressure (millimeters).[1]	Centimeters per second.	Seconds per centimeter.
40	1.84	1.0214	0.979
30	8.63	0.2414	4.143
20	40.99	0.0745	13.427
15	89.66	0.0503	19.874
[2] 11	168.00	0.0408	24.492
0	760.00	[3] 0.0259	38.603

[1] Humphreys, Jr. Frank. Inst. 165, p. 215, 1913.
[2] Isothermal level of middle latitudes.
[3] Temperature 21° C.

According to this table it appears that spherical grains of sand of the size assumed, 1.85 microns in diameter, would require about one year to fall from only that elevation already reached by balloons, 35.08 kilometers, down to the under surface of the isothermal region, at the height of 11 kilometers.

As a matter of fact volcanic dust, at least much of it, consists of thin-shelled bubbles or fine fragments of bubbles, and therefore must settle much slower than solid spheres, the kind above assumed. Indeed, the finest dust from Krakatoa, which reached a great altitude, probably not less than 40 nor more than 80 kilometers, was from 2½ to 3 years in reaching the earth, or, presumably, as above explained, the upper cloud levels.

At any rate volcanic dust is so fine, and the upper atmosphere above 11 kilometers so free from moisture and vertical convection, that once such dust is thrown into this region (as it obviously was by the explosions of Skaptar Jökull and Asamoyama in 1783, Babuyan in 1831, Krakatoa in 1883, Santa Maria and Pelé in 1902, Katmai in 1912, and many others), it must require as a rule, because of its slow descent, from 1 to 3 years to get back to the earth. And this clearly has always been the case since the earth first assumed substantially its present condition, or had a cool crust and a gaseous envelope.

Obviously, then, we have only to determine the present action of such dust on incoming solar and outgoing terrestrial radiation in order to reach a logical deduction as to what its effect on climate must have been if, through extensive volcanic activity, it ever for a long or even considerable term of years more or less continuously filled the upper atmosphere, as conceivably may have happened. And the same conclusion in regard to the possible effect of dust on the climates of the past clearly applies with equal force to the climates of the future.

Action of dust on solar radiation.—Since solar radiation at the point of maximum intensity[4] has a wave length less than 5×10^{-5} cm., or

[4] Abbot and Fowle, Annals Astrophys. Obsy. Smithsonian Inst., vol. 2, p. 104, 1908.

half a micron, and since fully three-fourths of the total solar energy belongs to spectral regions whose wave lengths are less than 10^{-4} cm., or 1 micron, it follows that the cubes of solar wave lengths must, on the whole, be regarded as small in comparison with the volume of a volcanic dust particle, the diameter of which, as we have seen, is nearly 2 microns. Hence in discussing the action of volcanic dust on incoming solar radiation we can, with more or less justification, assume the particles to be opaque through reflection or otherwise and therefore use Rayleigh's[1] arguments as applied to a similar case.

Let r be the radius of the particle, n be the number of particles per cubic centimeter, and a the projected joint area of these particles. Then, for random and sparse scattering

$$a = n\pi r^2$$

Hence, on dividing a plane parallel to the wave front into Fresnel zones, we see that for each centimeter traversed the amplitude of the radiation is reduced in the ratio of 1 to $1-n\pi r^2$, and, therefore, if A is the initial amplitude, and A_x the amplitude after passing through x centimeters of the uniformly dusty region, we have, assuming nr^2 to be only a small fraction of a square centimeter,

$$A_x = A\ (1-n\pi r^2)^x = Ae^{-n\pi r^2 x}$$

Further, if I is the initial and I_x the final intensity, then

$$I_x = Ie^{-2n\pi r^2 x}$$

Hence, in the case of volcanic dust, where, as already explained, $r = 92 \times 10^{-6}$ centimeter,

$$A_x = Ae^{-n\pi x (92)^2 10^{-12}}$$

and

$$I_x = Ie^{-2n\pi x\ (92)^2\ 10^{-12}}$$

Presumably the particles of dust are not absolutely opaque and therefore I_x probably is a little larger than the value here given, though even so this value is at least a first approximation.

Action of dust on terrestrial radiation.—Terrestrial radiation, at the point of maximum intensity, has a wave length of roughly 12×10^{-4} centimeters, and therefore the wave lengths of nearly all outgoing radiation are large in comparison with the diameters of those volcanic dust particles that remain long suspended in the atmosphere. Hence while such particles largely *reflect* solar radiation, as is obvious from the whiteness of the sky when filled by them, they can only *scatter* radiation from the earth according to the laws first

[1] Phil. Mag. 47, p. 375, 1899.

formulated by Rayleigh,[1] whose papers must be consulted by those who would fully understand the equations which here will be assumed and not derived.

Let E be the intensity of terrestrial radiation as it enters the dusty shell, or as it enters the isothermal region, and E_y its intensity after it has penetrated this region, supposed uniformly dusty, a distance y centimeters, then, remembering that the dust particles are supposed to be spherical, we have

$$E_y = Ee^{-hy}$$

where
$$h = 24\pi^3 n \frac{(K'-K)}{(K'+2K)^2} \cdot \frac{T^2}{\lambda^4},$$

in which n is the number of particles per cubic centimeter, K the dielectric constant of the medium, K' the dielectric constant of the material of the particles, T the volume of a single particle and λ the wave length of the radiation concerned.

But $K=1$, and, since the dust seems generally to be a kind of a glass, it may not be far wrong to assume that $K'=7$. Hence, with these values,

$$h = 11\pi^3 n \frac{T^2}{\lambda^4}, \text{ nearly.}$$

Relative action of dust on solar and terrestrial radiation—To determine whether such a dust layer as the one under discussion will increase or decrease earth temperatures, it is necessary to compare its action on short wave-length solar radiation with its action on long wave-length terrestrial radiation from the earth.

In the case of solar radiation, as explained,

$$I_x = Ie^{-2n\pi x(92)^2 10^{-12}}$$

Clearly, then, the intensity of the solar radiation is reduced in the ratio of 1 to e, or

$$I_x : I = 1 : e$$

when $x = \frac{10^{12}}{2n\pi(92)^2}$ centimeters $= \frac{188}{n}$ kilometers, approximately.

On the other hand, in the case of terrestrial radiation, where

$$E_y = Ee^{-11\pi^3 n \frac{T^2}{\lambda^4} y}$$

the intensity is reduced in the ratio of $1:e$, or

$$E_y : E = 1 : e$$

when

$$y = \frac{\lambda^4}{11\pi^3 n T^2} \text{ centimeters,}$$

[1] l. c.

in which

$$T=\frac{4}{3}\pi(92)^3 10^{-18}$$

and

$$\lambda=12\times10^{-4}, \text{ the region of maximum intensity.}$$

Hence

$$y=\frac{5700}{n} \text{ kilometers, approximately.}$$

Therefore, finally,

$$y:x=30:1 \text{ roughly,}$$

or the shell of volcanic dust, the particles all being the size given, is some thirtyfold more effective in shutting solar radiation out than it is in keeping terrestrial radiation in. In other words, the veil of dust produces an inverse greenhouse effect, and hence, if the dust veil were indefinitely maintained, the ultimate equilibrium temperature of the earth would be lower than it is when no such veil exists.

The ratio of 30 to 1 in favor of terrestrial radiation in its ability to penetrate the dusty atmosphere may at first seem quite too large, but it should be remembered that the dust particles in question are to terrestrial radiation in general, as air molecules are to solar radiation, in the sense that in both cases but little more than mere scattering takes place. Now, it is obvious that the dust particles are manyfold more effective in intercepting solar radiation, which they appear to do chiefly by reflection, than are an equal number of air molecules which simply scatter it, and hence it may well be that the above theoretically determined ratio 30 to 1 is no larger than the ratio that actually exists, or at any rate that it is of the correct order.

It must be distinctly understood that certain of the assumptions upon which the foregoing is based, for instance, uniformity of size, complete opacity, and sphericity of the dust particles, are only approximately correct, but at present they are the best that can be made, and doubtless give at least the order of magnitude of the effects, which, indeed, for the present purpose is quite sufficient.

It may be well in this connection to call attention to the fact that excessively fine dust particles, or particles whose diameters are half, or less, the wave length of solar radiation (region of maximum intensity) and which therefore remain longest in suspension, shut out solar radiation manyfold more effectively than they hold back terrestrial radiation. This is because both radiations, solar and terrestrial, are simply scattered by such small particles, and scattered according to the inverse fourth power of the wave length.

Now, the ratio of solar wave length to terrestrial wave length (region of maximum intensity in both cases) is roughly 1 to 25, and therefore the ratio of their fourth powers as 1 to 39×10^4, about.

Hence, in the case of the very finest and therefore most persistent dust, the interception of outgoing radiation is wholly negligible in comparison with the interception of incoming solar radiation.

Let us next see what observational evidence, pyrheliometric or other kind, we have bearing on the effect of volcanic dust on radiation.

Pyrheliometric records.—Direct measurement of solar radiation by means of the pyrheliometer shows marked fluctuations from year to year in the intensity of this radiation as received at the surface of the earth. This subject has been carefully studied by Dr. H. H. Kimball,[1] of the United States Weather Bureau, and figure 1 kindly prepared by him for use in this article, graphically represents the course of pyrheliometric readings from the beginning of 1883 till and including 1913. The yearly values are given in terms of the average value for the entire period and, therefore, percentages of this average do not represent the full effect of the disturbing causes, of which volcanic dust certainly is the chief.

The marked decrease in the pyrheliometric readings for 1884, 1885, and 1886 doubtless were largely if not almost wholly due to the

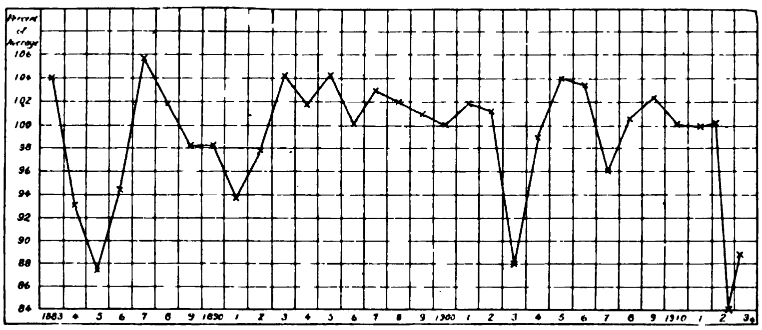


FIG. 1.—Annual average pyrheliometric values.

eruption of Krakatoa in the summer of 1883; the decreased values of 1888 to 1892, inclusive, occurred during a period of exceptional volcanic activity but were most probably due essentially to the violent eruptions of Bandaisan (1888), Bogoslof (1890), and Awoe on Great Sangir (1892); the low values of 1903 to the eruptions of Santa Maria, Pelé, and Colima; and the present low values, 1912–13, to the recent (1912) explosion of Katmai.

There is, then, abundant pyrheliometric evidence that volcanic dust in the upper atmosphere actually does produce that decrease in direct solar radiation that theory indicates it should, and, as the theory is well founded and the observations carefully taken, this mutual confirmation may be regarded as conclusive both of the existence of volcanic dust in the upper atmosphere (isothermal

[1] Bull. Mt. Weather Obsy., 3, p. 69, 1910.

region) and of its efficiency in intercepting direct radiation from the sun.

It should be remembered, however, in this connection that the intensity of the solar radiation at the surface of the earth depends upon not only the dustiness of the earth's atmosphere but also upon the dustiness, and of course the temperature, of the solar atmosphere.

Obviously dust in the sun's envelope must more or less shut in solar radiation just as and in the same manner that dust in the earth's envelope shuts it out. Hence it follows that when this dust is greatest, other things being equal, the output of solar energy will be least, and that when the dust is least, other things being equal, the output of energy will be greatest. Not only may the intensity of the emitted radiation vary because of changes in the transparency of the solar atmosphere but also because of any variations in the temperature of the effective solar surface which, it would seem, might well be hottest when most agitated, or at the times of spot maxima, and coolest when most quiescent, or at the times of spot minima.

Now, the dustiness of the solar atmosphere, manifesting itself as a corona, certainly does vary through a considerable range from a maximum when the sun spots are most numerous to a minimum when they are fewest, and therefore, partly because of changes in the transparancy of the solar envelope and partly because of changes in the solar surface temperature, if, as in all probability they do, such temperature changes take place we should expect the solar constant also to vary from one value at the time of spot maximum to another at the time of spot minimum and to vary as determined by the controlling factor, dust or temperature..

If the above reasoning is correct, it follows that pyrheliometric readings are, among other things, functions of both the solar atmosphere and our own terrestrial atmosphere; and as the former is altered chiefly by sun spots, or at least varies with their production and existence, and the latter by volcanic explosions, a means is at hand for comparing the relative importance of the two radiation screens. Figure 2 shows one such comparison. The upper curve gives smoothed annual average pyrheliometric readings (not solar constants, though closely proportional to them) and the lower curve sun-spot numbers. It will be noticed that in their most pronounced features the two curves have but little in common and that the great drops in the pyrheliometric values occur simultaneously with violent volcanic explosions, as already explained, and not at the times of sun-spot changes. Hence it appears that the dust in our own atmosphere, and not the condition of the sun, is the controlling factor in determining the magnitudes and times of occurrence of great and abrupt changes of insolation intensity at the surface of the earth.

This is what the curves positively show, but it is not all they indicate. From 1894 to 1901 there were no volcanic explosions, so far as known, of importance, and therefore during this time the upper atmosphere must have been more or less uniformly free from dust. But there seems to have been during this interval a slow decrease in pyrheliometric values, and presumably therefore in the solar constant; also during exactly this same interval the number of sun spots slowly decreased. Again, from 1905 to 1911, the same general trends of the curves, a decrease in pyrheliometric values simultaneously with a decrease in sun spots, repeat themselves. Hence the indication—it is impossible yet to call it a certainty—seems to be that the solar constant, and hence presumably the effective surface tempera-

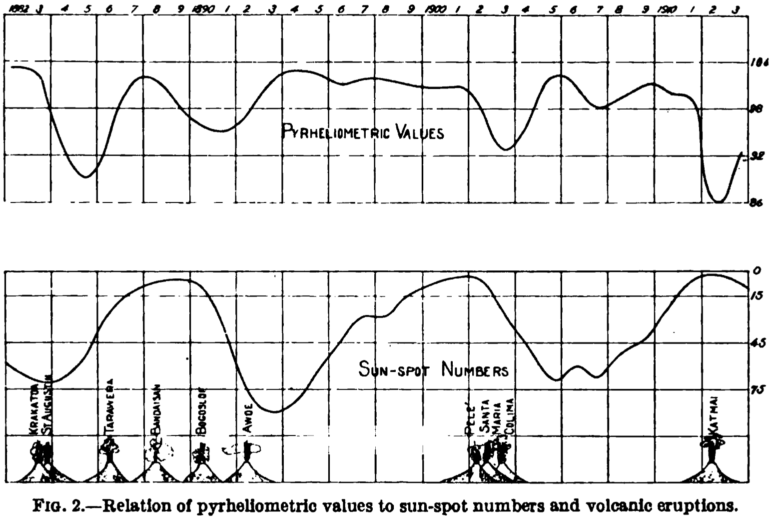


FIG. 2.—Relation of pyrheliometric values to sun-spot numbers and volcanic eruptions.

ture of the sun, is a little though not much greater at the times of spot maxima than at the times of spot minima.

Surface temperatures.—If a veil of dust actually should intercept as much as one-fifth of the direct solar radiation, as Fig. 1 indicates that at times it does, it would seem that in those years the surface temperatures of the atmosphere should be somewhat below the normal. Of course the great supply of heat in the ocean would produce a lag in this effect, and besides there must be both an increase of sky light by scattering and some interception of earth radiation by the dust which, since it is at great altitudes, receives the full or nearly the full planetary radiation of the earth. This increase of sky radiation, together with the return terrestrial radiation, obviously compensates in some measure for the loss of direct insolation.

However, measurements made by Abbot[1] at Bassour, Algeria, during the summer of 1912 show that at this time and place the direct radiation and the sky radiation, which obviously included both the scattered solar radiation and some return terrestrial radiation, were together less by about 10 per cent than their normal combined values; and there is no reason to think that in this respect Bassour was at all different from other places, probably the whole earth, covered by the veil of dust. Clearly, then, if this decrease in the radiation received should continue indefinitely, the ultimate radiation of the earth would also decrease to the same extent, or 10 per cent. Now since the earth, or rather the water vapor of the atmosphere, radiates substantially as a black body and therefore as the fourth power of its absolute temperature, it follows that a 10 per cent change in its radiation would indicate about a 2.5 per cent change in its temperature. But the effective temperature of the earth as a full radiator, which it closely approaches, is about 256° C.[2] Hence a change of 10 per cent in the radiation emitted would imply 6.4° C. change in temperature, an amount which, if long enough continued, would be more than sufficient to produce glaciation equal to the most extensive of any known ice age.

As above implied, not much lowering of the temperature could be expected to take place immediately, but still some cooling might well be anticipated. To test this point the temperature records of a number of high altitude (together with two or three very dry) inland stations have been examined. High altitudes were chosen because it might be expected that the temperature contrast between normal and dusty years would be greatest where the amount of atmosphere traversed below the dust layer is least; and the condition that the station should also be inland was imposed because these are freer, presumably, than many coast stations, from fortuitous season changes. Thus, stations in the eastern portion of the United States are rejected because of the great differences in the winters, for example, of this section depending upon conditions wholly independent, so far as known, of variations in the intensity of direct radiation.

The number of stations was still further limited by the available recent data. Hence the records finally selected, and kindly put in shape by the Climatological Division of the United States Weather Bureau, Mr. P. C. Day in charge, for use in this article, were obtained at the following places:

[1] Smithsonian Miscellaneous Collections, Vol. 60, No. 29.
[2] Abbot and Fowle. Annals, etc. Vol. 2, p. 175, 1908.

TABLE I.—*Stations whose data were used.*

AMERICA.

Name.	Latitude N.		Longitude W.		Elevation.
	°	′	°	′	*Feet.*
Baker	44	46	117	50	3,466
Bismarck	46	47	100	38	1,674
Cheyenne	41	08	104	48	6,088
Denver	39	45	105	00	5,291
Dodge City	37	45	100	00	2,509
El Paso	31	47	106	30	3,762
Helena	46	34	112	04	4,110
Huron	44	21	98	14	1,306
North Platte	41	08	100	45	2,821
Red Bluff	40	10	122	15	332
Sacramento	38	35	121	30	69
Salt Lake City	40	46	111	54	4,360
San Antonio	29	27	98	28	701
Santa Fe	35	41	105	57	7,013
Spokane	47	40	117	25	1,929
Winnemucca	40	58	117	43	4,344
Yuma	32	45	114	36	141

EUROPE.

Name.	Latitude N.		Longitude W.		Elevation.
Mont Ventoux	44	10	5	16	6,234
Obir	46	30	14	29	6,716
Pic du Midi	42	56	0	8	9,380
Puy de Dôme	45	46	2	57	4,813
Säntis	47	15	9	20	8,202
Schneekoppe	50	44	15	44	5,359
Sonnblick	47	03	12	57	10,190

INDIA.

Name.	Latitude N.		Longitude W.		Elevation.
Simla	31	06	77	12	7,232

TABLE II.—*Average temperature departures from temperature normals—America.*

Year.	Maxima.		Minima.		Means.	
	Actual.	Smoothed.	Actual.	Smoothed.	Actual.	Smoothed.
	°F.	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*
1880	−1.3	+0.03	−1.8	−0.68	−1.7	−0.50
1881	+0.2	−0.30	+0.6	−0.20	+0.1	−0.48
1882	−0.3	−0.50	−0.2	−0.20	−0.4	−0.50
1883	−1.6	−1.33	−1.0	−0.70	−1.3	−1.15
1884	−1.8	−1.20	−0.6	−0.28	−1.6	−1.05
1885	+0.4	−0.18	+1.1	+0.43	+0.3	−0.30
1886	+0.3	+0.35	+0.1	+0.10	−0.2	−0.03
1887	+0.4	+0.38	−0.9	−0.45	0.0	+0.07
1888	+0.4	+0.53	−0.1	−0.13	+0.5	+0.53
1889	+0.9	+0.63	+0.6	+0.23	+1.1	+0.85
1890	+0.3	+0.15	−0.2	−0.05	+0.7	+0.58
1891	−0.9	−0.58	−0.4	−0.38	−0.2	+0.05
1892	−0.8	−0.85	−0.1	−0.33	−0.1	−0.20
1893	−0.9	−0.73	−0.7	−0.38	−0.4	−0.08
1894	−0.3	−0.55	+0.4	−0.18	+0.6	+0.13
1895	−0.7	−0.35	−0.8	−0.08	−0.3	+0.25
1896	+0.3	−0.18	+0.9	+0.28	+1.0	+0.45
1897	−0.6	−0.30	+0.1	+0.13	+0.1	+0.28
1898	−0.3	−0.65	−0.6	−0.45	−0.1	−0.13
1899	−0.8	−0.13	−0.7	−0.10	−0.4	+0.25
1900	+1.4	+0.78	+1.6	+0.90	+1.9	+1.23
1901	+1.1	+0.83	+1.1	+1.08	+1.5	+1.35
1902	−0.3	−0.13	+0.5	+0.38	+0.5	+0.53
1903	−1.0	−0.43	−0.6	−0.05	−0.4	+0.18
1904	+0.6	−0.15	+0.5	+0.05	+1.0	+0.38
1905	−0.8	−0.30	−0.2	+0.08	−0.1	+0.33
1906	−0.2	−0.30	+0.2	+0.08	+0.5	+0.33
1907	0.0	+0.10	+0.1	+0.10	+0.4	+0.50
1908	+0.6	+0.15	0.0	−0.08	+0.7	+0.43
1909	−0.6	+0.38	−0.4	−0.05	−0.1	+0.55
1910	+2.1	+0.80	+0.6	+0.08	+1.7	+0.75
1911	−0.4	+0.03	−0.5	−0.35	−0.3	+0.05
1912	−1.2	−0.70	−1.0	−0.63	−0.9	−0.53

TABLE III.—*Weighted departures of mean temperatures from normal temperatures—World.*

Date.	Actual.	Smoothed.	Date.	Actual.	Smoothed.
	°F.	°F.		°F.	°F.
1872	−0.78	−0.30	1893	−0.34	−0.06
1873	−0.65	−0.47	1894	+0.34	+0.03
1874	+0.20	−0.34	1895	−0.21	+0.10
1875	−1.12	−0.61	1896	+0.49	+0.28
1876	−0.40	−0.60	1897	+0.34	+0.45
1877	−0.48	−0.32	1898	+0.61	+0.46
1878	+0.07	0.00	1899	+0.27	+0.59
1879	+0.33	+0.04	1900	+1.19	+0.76
1880	−0.50	−0.13	1901	+0.40	+0.55
1881	+0.14	−0.02	1902	+0.20	+0.13
1882	+0.14	−0.16	1903	−0.30	+0.10
1883	−1.04	−0.68	1904	+0.81	+0.20
1884	−0.79	−0.61	1905	−0.51	+0.01
1885	+0.17	−0.09	1906	+0.23	+0.05
1886	+0.11	+0.03	1907	+0.23	+0.30
1887	−0.29	−0.05	1908	+0.51	+0.21
1888	+0.26	+0.24	1909	−0.43	+0.11
1889	+0.74	+0.57	1910	+0.69	+0.30
1890	+0.54	+0.40	1911	+0.23	+0.09
1891	−0.21	+0.06	1912	−0.80	−0.40
1892	+0.10	−0.09			

In Table II the first column gives the year in question. The second column gives the average departure in degrees F. for the 17 American stations, of the annual average maximum, as determined from the monthly average maxima, from the normal annual maximum, or average of a great many annual average maxima. The third column gives smoothed values, determined from the actual values in the second column, as follows:

$$S = \frac{a + 2b + c}{4}$$

in which S is the smoothed value, b the actual value pertaining to the particular year for which S is being computed, a and c the actual values for the next previous and the next succeeding years, respectively. The fourth and fifth columns give, respectively, the actual and the smoothed average departures of the annual average minima, while the sixth and seventh columns give the corresponding average departures of the annual average means.

Figure 3 shows the graphical equivalents of the smoothed portions of Table II.

It will be noticed that the three curves of Fig. 3, marked max., min., and mean, respectively, are in general quite similar to each other. Hence because of this mutual check and general agreement we feel reasonably certain that any one set of temperature data, the means for instance, furnishes a fairly safe guide to the actual temperature and climatic fluctuations from year to year or period to period.

Table III gives the weighted actual average departures and the smoothed departures in degrees F. of the annual mean temperatures of the selected 17 American, 7 European, and 1 Indian station listed in Table I.

The average departures were calculated in accordance with the more or less correctly coefficiented equation,

$$D=\frac{4A+2E+I}{7}$$

in which D is the weighted departure, A the smoothed average American, E the smoothed average European, and I the smoothed Indian departure of the mean annual temperature from the normal annual temperature.

Table III extended, as well as the scanty early data, mainly from the given stations, will permit, back to 1872, is graphically represented by the continuous light curve at the bottom of Fig. 4. In 1880 and again in 1901 the curve probably does not very closely

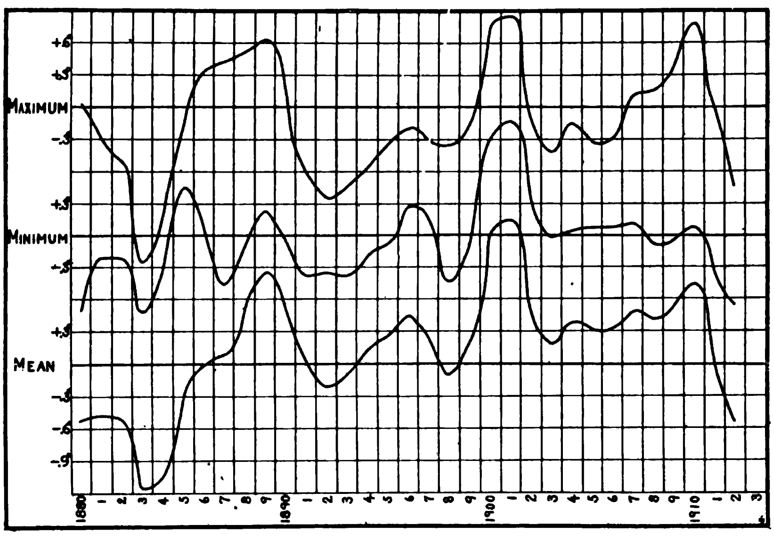


FIG. 3.—Smoothed averages of the annual average temperature departures of 17 American stations.

represent world-wide temperature departures, being, presumably, at both places quite too low, owing, in each case, to an abnormally cold single month in America.

From 1906 to 1911 the dotted curve gives the average temperature departures for the American stations only, and presumably represents world temperature departures much more closely than does the continuous light line for the same time. This is because of two or three exceptionally cold summer months in Europe.

The dotted curve from 1872 to 1900 gives the smoothed averages of the annual temperature departures from the normal temperatures of the following stations as computed from the actual departures given by Nordmann:[1] Sierra Leone, Recife (or Pernambuco), Port

[1] Revue Général des Sciences, August, 1903, pp. 803-808. Annual Report, Smithsonian Institution, 1903, pp. 139-149.

au Prince, Trinite, Jamaica, Habana, Manila, Hongkong, Zikawei, Batavia, Bombay, island of Rodriguez, island of Mauritius.

All these, or practically all, are low-level stations, and most of them either tropical or semitropical, and therefore should show in general a smaller temperature range than the high-altitude stations whose temperature departures are given by the continuous fine line curve. Hence, all things considered, the average temperature departures as calculated from the two sets of stations agree remarkably well, so that one can say with a fair degree of confidence that the heavy curve *T* approximately represents the average of the departures of the mean annual temperatures from the normal annual

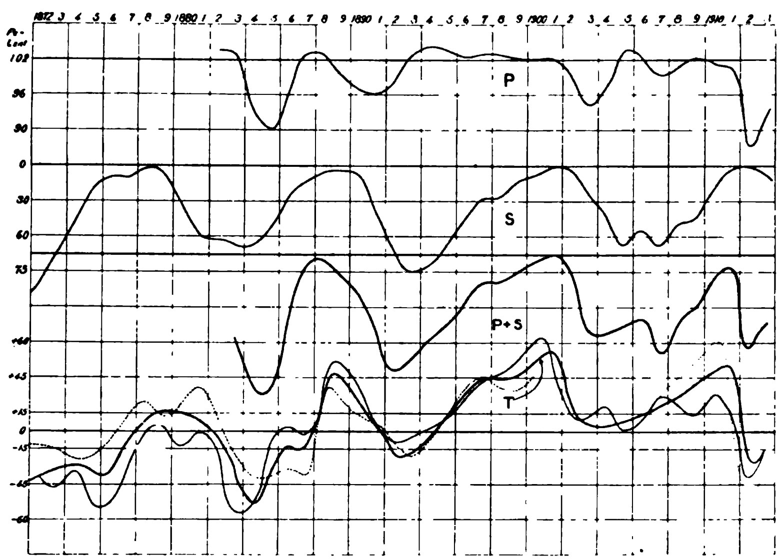


FIG. 4.—Smoothed pyrheliometric, sun spot, and temperature curves.

temperatures of the entire earth, or that *T* is the curve of world temperatures.

Relation of world temperatures to pyrheliometric values.—Curve *P*, also of Fig. 4, gives the smoothed course of the annual average pyrheliometric readings as computed from the actual values given in Fig. 1. The insolation intensity data covering the whole of the depression that has its minimum in 1885 was obtained at a single place, Montpellier, France, by a single observer, L. J. Eon,[1] who confined himself to noon observations with a Crova actinometer. It may be, therefore, that merely local and temporary disturbances produced a local insolation curve that was not quite parallel to the curve for the entire world. At any rate, the drop in the solar radiation values obviously was due to dust put into the atmosphere by the explosion of Krakatoa in August, 1883, and it would seem

[1] Bulletin météorologique du Département de l'Herault, 1900.

that the effects of this dust both on the surface temperatures and on pyrheliometric values must have been greater during the latter part of 1883 and in 1884 than they were in 1885, when much of the dust certainly had already settled out of the atmosphere, and this supposition is well supported by the pyrheliometric and temperature drops that immediately followed the volcanic explosions of 1903 and 1912, and their partial recovery within a single year. Nevertheless the pyrheliometric values must be accepted as obtained. Indeed, they appear to be somewhat supported by the fact that the coldest year following the similar, though more violent, explosion of Asamoyama, just 100 years earlier, was not the year of the explosion, 1783, nor the following year, but 1785.

It is probable that in the earlier, as certainly in the later, of these unusual cases the dust was thrown to such great altitudes that the finer portions were nearly or quite two years in reaching the lower level of the isothermal region. Clearly, too, much of this dust, while perfectly dry, probably was so fine as merely to scatter even solar radiation, and yet on reaching the humid portions of the atmosphere the particles may have gathered sufficient moisture to assume reflecting size, and therefore seriously to interfere with insolation. This is merely suggested, but in no wise insisted upon, as a possible explanation of the unusual pyrheliometric lag after the explosion of Krakatoa.

It is obvious from a mere glance that the pyrheliometric and the temperature curves, or curves P and T, have much in common. This is especially marked by the large and practically simultaneous drops in the two curves in 1912 following the eruption of Katmai. But while a relation between these curves thus appears certain, the agreement is so far from perfect as to force the conclusion that pyrheliometric values constitute only one factor in the determination of average world temperatures.

Sun spots and temperature.—It has been known for a long time that the curve of sun-spot numbers, curve S, Fig. 4, and the curve of earth temperatures, curve T, follow or parallel each other in a general way, in the sense that the fewer the spots the higher the temperature, with, however, puzzling discrepancies here and there. Both these facts, the general agreement between the phenomena in question and also their specific discrepancies, are well shown by the curves S and T of Fig. 4, and while the discrepancies are marked, it is obvious that on the whole the agreement is quite too close to leave any doubt of the reality of some sort of connection between sun spots and atmospheric temperatures. Just how or by what process this relation exists will be discussed below.

Combined effect of insolation intensity and sun-spot influence on atmospheric temperatures.—Since it is obvious that the insolation

intensity and the number of sun spots each exerts an influence on the temperature of the earth, it is clear that some sort of a combination of the two curves P and S should more closely parallel the temperature curve T than does either alone. It is probable that the sun-spot effect is not directly proportional to the actual number of spots, but, however this may be, the direct combination of the curves P and S gives the resultant $P+S$, which, as a glance at the figure shows, actually parallels the curve of temperatures T with remarkable fidelity. Exactly this same combination from 1880 to 1909 has just been made by Abbot and Fowle,[1] whose lead in this important particular is here being followed and the resultant curve found to run closely parallel to the curve of "smoothed annual mean departures" of the maximum temperatures of 15 stations in the United States.

Probably the most striking point of agreement, as shown by Fig. 4, between the combination curve and the temperature curve, occurs in 1912, where, in spite of the fact that the sun spots were at a minimum, the temperature curve dropped greatly and abruptly; obviously because of the simultaneous and corresponding decrease in the intensity of solar radiation produced by the extensive (presumably world-wide) veil of Katmai's dust.

Temperature variations since 1750 as influenced by sun spots and volcanic eruptions.—Sun-spot numbers[2] month by month are fairly well known since July, 1749, and so too are the annual temperature variations[3] from about the same time, and therefore the data are at hand for comparing these two phenomena over a continuous period of a little more than 163 years, or from at least the beginning of the year 1750 to the present date. Fig. 5 makes this comparison easy. The bottom curve gives the smoothed annual temperature departures, as computed from Köppen's actual annual departures, using all stations, while the top curve follows Wolfer's annual average sun-spot numbers.[4] Of course the earlier observations, both of sun spots and of temperatures, were few in number and more or less unsatisfactory in comparison with those obtained during the past 30 or even 40 years. Nevertheless it is clear from Fig. 5 that at least since 1750, the date of our earliest records, and presumably therefore since an indefinitely distant time in the past, the two phenomena, atmospheric temperature and sun-spot numbers, have in general varied together, with, however, marked discrepancies from time to time. These we shall now consider and show that they occurred in every important case simultaneously with violent volcanic eruptions.

[1] Smithsonian Miscellaneous Collections, vol. 60, no. 29, 1913.

[2] Wolfer, Astronomische Mitteilungen, 93, 1902, and later numbers.

[3] Köppen, Zeit. Österreich. Gesell. für Meterologie, vol. 8, pp. 241, 257, 1873.

[4] NOTE BY THE EDITOR.—The first authoritative publication of the revised list of *observed* and of *smoothed* sun-spot numbers, respectively, and of the remarks by Prof. A. Wolfer, will be found on pp. 171–176 of the Monthly Weather Review for April, 1902, with a graphic diagram that was subsequently reprinted in the Astronomische Nachrichten.—C. A.

Volcanic disturbances of atmospheric temperature since 1750.—It must be distinctly remembered that the earlier temperature records, because of their limited number, if for no other reason, can give us only the general trend of world temperatures. Again, the record back to 1750 of even violent volcanic eruptions is necessarily incomplete; and, besides, not all great eruptions decrease the world's temperature—only those that drive a lot of dust into the isothermal region. Extensive and long-continued sky phenomena, therefore, of the type that followed the eruption of Krakatoa, furnish the best evidence of volcanic violence in the sense here used. Finally, there can be no particular test save where the temperature is low in comparison with that which the number of sun spots would lead us to expect. Obviously then, no matter how close the actual relation between the phenomena may be, the errors and the incompleteness of the recorded data would prevent the discovery of more than a general relation.

Of course it will naturally occur to one to ask about special cases, such as the cold years of 1783–84–85, and, in particular, 1816, the famous "year without a summer," "poverty year," or "eighteen hundred and froze to death." The first of these, 1783–85, followed, as already explained, the great explosion of Asama in 1783, while the second, the "year without a summer," that was cold the world over, followed the eruption of Tomboro, which was so violent that 56,000 people were killed,[1] and "for three days there was darkness at a distance of 300 miles."[2]

There is a detail in the temperature curve for the years 1886–87, that needs special attention. The temporary depression where, seemingly, the temperature should be steadily rising obviously was due to the great eruption of Tarawera in New Zealand. This volcano is a little more than 38° south of the equator, and therefore furnished a good example of an eruption on one side of the equator affecting the temperature far to the other side.

But if the temperature was decreased by Tarawera, why, one might ask, was not the pyrheliometric curve similarly affected? It was, for several months after the eruption, as the individual monthly values show, but the annual means, plotted in the figure, have the effect of making the pyrheliometric disturbance from Tarawera appear only as a retardation in the recovery from Krakatoa.

Neglecting the smaller irregularities which may or may not have been of world-wide occurrence, and remembering that, other things being equal, we may expect temperature maxima at the times of spot minima and temperature minima at the times of spot maxima, we can tabulate as follows the marked discrepancies and their probable explanations:

[1] Schneider, Die Vulcanischen Erscheinungen der Erde, p. 1, 1911.
[2] Report Krakatoa Committee Royal Society, 1888, p. 393.

Temperature and sun-spot discrepancies.

Date.	Nature of discrepancy.	Probable cause.
1755–6	Cold	Kötlugia, Iceland, 1755.
1766–7	Cold	Hecla, Iceland, 1766. Mayon, Luzon, 1766.
1778–9	Warm	Maximum number (annual) of sun spots ever recorded and unusually short spot period. Can it be that the solar constant actually was distinctly greater than usual at this time?
1784–5–6	Cold	ASAMA,[1] Japan, 1783. The most frightful eruption on record. Skaptar Jökull, Iceland, 1783. Vesuvius, Italy, 1785.
1799	Cold	Fuego (?), Guatemala. (Uncertain.)
1809	Cold	St. George (?), Azores, 1808. (Uncertain.) Etna (?), Sicily, 1809. (Uncertain.)
1812–13–14–15–16.	Cold	Soufrière, St. Vincent, 1812. Mayon, Luzon, 1814. TOMBORO,[1] Sumbawa, 1815; very great.
1831–2	Cold	Graham's Island, 1831. Babujan Islands, 1831. Pichincha, Ecuador, 1831.
1856–7	Cold	Cotopaxi (?), and others, 1855–6. (Uncertain.)
1372–3	Cold	Vesuvius, Italy, 1872. Merapi, Java, 1872.
1875–6	Cold	Vatna Jökull, Iceland, 1875.
1884–5–6	Cold	KRAKATOA,[1] Strait of Sunda, 1883; greatest since 1783. St. Augustin, Alaska, 1883. Tarawera, New Zealand, 1886.
1890–1–2	Cold	Bogoslof, Aleutian Islands, 1890. Awoe, Great Sangir, 1892.
1902–3–4	Cold	Pelé, Martinique, 1902. Santa Maria, Guatemala, 1902. Colima, Mexico, 1903.
1912–13	Cold	Katmai, Alaska, 1912.

[1] Exceptionally violent.

The above list does not dispose of all the seeming irregularities, nor of all the known volcanic eruptions; but it does dispose of all the well-defined and unquestioned irregularities and also of every one of the known really great volcanic explosions since 1750.

We may conclude, therefore, that the variations in the average temperature of the atmosphere depend jointly upon volcanic eruptions, through the action of dust on radiation, as already explained, and upon sun-spot numbers, through, presumably, some intermediate action they have upon the atmosphere—possibly of the nature we shall now explain.

How sun spots may change earth temperatures.—If the solar constant remains the same from spot maximum to spot minimum, it clearly is not easy to see at a glance why the surface temperature of the earth should vary as it does with spot numbers; and the situation is still more difficult if, as observations appear to indicate, our lowest temperatures occur when the solar constant is greatest and our highest temperatures when this constant is least. There is, however, a possible explanation of the paradox, and while it may not contain the whole truth, it nevertheless is sufficient to show *a priori* that in all probability our temperatures do change from spot maxima to spot minima without a corresponding change in the solar constant, and also to show that a decrease in our surface temperatures may accompany even a slight increase in the solar constant.

The explanation in question has already been given elsewhere,[1] and the original paper must be consulted by those who wish to weigh all the details of the argument. Briefly, however, the argument is as follows:

1. At the times of spot maxima the solar corona is much more extensive than it is at the times of spot minima—a well-known observation.

2. This corona consists in part at least of reflecting particles, as many eclipse observations have shown, and so may be regarded as dust in the solar atmosphere.

3. The brightness of the sun, as every solar observer knows, drops off from center to limb.

4. This drop, as reported by various observers, is greater the shorter the wave length, and due, almost certainly, to diffuse scattering.

From these observational facts it follows that during spot minima, other things being equal, the solar spectrum must necessarily be richer in violet and ultra-violet radiation than it is during spot maxima.

But, as experiment has shown,[2] ultra-violet radiation of shorter wave length than λ 1850 is strongly absorbed by oxygen, with the result that some of the oxygen is converted into ozone. Hence, since the atmosphere of the isothermal region is cold and dry (conditions favorable to the stability of ozone) and since of the gases of the upper atmosphere only oxygen is appreciably absorptive of radiations between λ 1250 and λ 1900,[3] we should confidently expect it to contain more or less ozone, an expectation greatly strengthened by the observations of Fabry and Buisson,[4] though already virtually confirmed by Ångström.[5] In so far, then, as this ozone is produced by ultra-violet radiation, we should also very definitely expect it to be greater in quantity when the very short wave-length radiation to which it is due is most intense, or presumably, therefore, at the times of spot minima. Now, according to the experiments of Ladenburg and Lehmann,[6] while ozone is somewhat absorptive of solar radiation it is several fold more absorptive, in fact highly absorptive, of terrestrial radiation. Hence in this case, as in the case of the absorption of radiation by dust, already considered, equation A (p. 7) is applicable.

In this equation let a be the coefficient of absorption of the ozone in the isothermal region for solar radiation and b its coefficient of absorption for earth radiation. To be definite, let $a=0.02$ and $b=0.10$ at the time of a spot maximum, and for a spot minimum let

[1] Humphreys, Astrophys. Jr. 32, p. 97, 1910.

[2] Lyman, Astrophys. Jr. 27, p. 87, 1908.

[3] Lyman, l. c.

[4] C. R. 156, p. 782, 1913; Journal de Physique, 3, p. 196, 1913.

[5] Arkiv för Matematik, Astronomi och Fysik, 1, p. 395, 1904.

[6] Annalen der Physik, 21, p. 305, 1906.

$a=0.03$ and $b=0.15$, quantities that would require really very little ozone. Then, remembering that the earth radiates practically as a full radiator, or black body, at the absolute temperature 256° C., and taking T_{max} and T_{min} as the equilibrium temperatures at the time of spot maximum and spot minimum, respectively, we get

$$\left(\frac{T_{max}}{256}\right)^4=\frac{521}{500};\quad T_{max}=258°.65$$

and

$$\left(\frac{T_{min}}{256}\right)^4=\frac{2129}{2000};\quad T_{min}=260°.05.$$

That is, under these conditions, and if the solar constant should remain exactly the same, the temperature at the time of spot minimum would be 1°.4 C. warmer than at the time of spot maximum. Hence even a slight increase in the solar constant at the time of spot maximum might still leave the temperature a trifle cooler than at the time of spot minimum.

Of course it is not claimed that the above gives, both quantitatively and qualitatively, exactly what happens, but itis claimed that it does show qualitatively what might happen and, so far as we can judge from observations and laboratory experiments, what actually must happen.

Influence of carbon dioxide on temperature.—It was stated in the early part of this paper, under the carbon dioxide theory of ice ages, that the question of the possible effect a change in the amount of carbon dioxide in the atmosphere might have on temperatures would be taken up later. The way to this is now open through the above discussion of ozone. Like ozone, carbon dioxide also is more absorptive of terrestrial radiation than of solar energy. Hence increasing the carbon dioxide in the atmosphere, and thereby increasing its amount in the isothermal region where we can treat it as a shell external to the radiating earth, obviously must have the same general effect on the temperature of the earth as increasing the ozone of this region would have. That is, other things being equal, a greater or less temperature increase would follow the introduction into the atmosphere of a larger amount of carbon dioxide.

Because of the constant mixing caused by vertical convection it is probable that the percentage of carbon dioxide is very nearly as great at the under surface of the isothermal region as it is at the surface of the earth. If so, then the carbon dioxide of the isothermal region is equivalent, roughly, to a layer 40 centimeters thick at normal atmospheric pressure. In high latitudes, where the isothermal level is low, the equivalent layer probably is thicker than this and in equatorial regions probably thinner. Now, according to the experiments of Schlaefer,[1] a layer of carbon dioxide 40 centimeters thick is sufficient

[1] Ann. der Physik, 16, p. 93, 1905.

to produce very nearly full absorption, and therefore no increase in the amount of carbon dioxide in the atmosphere could very much increase its temperature.

An approximate idea of the possible temperature change of the lower atmosphere as a result of the presence of carbon dioxide in the isothermal region can be obtained from known data. Thus Abbot and Fowle[1] have computed that carbon dioxide may absorb 14 per cent of the radiation from a black body at the temperature of 282°.2 C. absolute. But as this is not many degrees, 25 or so, above the effective temperature of the earth as a radiator, it follows that 14 per cent is, roughly, the upper limit to which terrestrial radiation can be absorbed by carbon dioxide in the isothermal region, while its absorption of solar radiation is very nearly negligible.

Assuming that the present amount of carbon dioxide in the isothermal region absorbs 1 per cent of the solar radiation and 10 per cent of the outgoing earth radiation (values that seem to be roughly of the correct order), and using equation A as above, it will be seen, if the experiments here referred to and the assumptions are substantially correct, that doubling or even multiplying by several fold the present amount of carbon dioxide could increase the average temperature by no more than about 1°.3 C. Similarly, reducing the carbon dioxide by one-half could decrease the temperature by no more than approximately the same amount, 1°.3 C.

It is not certain to what extent the percentage of carbon dioxide in the atmosphere has actually varied during the geological past, but, if the above reasoning is correct, it seems that our surface temperatures could never have been much increased above their present value through the action of this particular agent alone. Further, the fact, so far as known, that within the Tropics at least plant growth, even during the ice ages, was quite as vigorous during the past as it is at present, shows that for many ages carbon dioxide has been abundant in the atmosphere—probably never much less abundant than at present. Hence it seems likely that a decrease in temperature of a fraction of one degree is all that can reasonably be accounted for in this way.

Finally, if the above reasoning is correct, it seems that changes in the amount of carbon dioxide in the atmosphere might have been a factor in the production of certain climatic changes of the past, but that it could not, of itself, have produced the ice ages.

Having considered, in the above long digressions, the observational evidence of temperature changes in connection with volcanic explosions, we are ready again to take up the main subject and to consider one or two more of the physical problems it presents.

[1] Annals Astrophys. Obsy. Smithsonian Inst., vol. 2, p. 172, 1908.

Number of dust particles.—The intensity of the solar radiation I_x after it has passed through x centimeters of the dusty layer of the atmosphere is given, as we have seen, by the equation

$$I_x = Ie^{-2n\pi x(92)^2 10^{-12}}$$

But, according to numerous observations made during the summer and fall of 1912, when the solar radiation had passed entirely through the dust layer at such an angle that it met roughly twice as many dust particles as it would have met had it come in normally, or from the zenith, it was reduced by about 20 per cent. That is to say, under these conditions

$$I_x = 0.8 \text{ I}$$

Hence

$$10 = 8e^{-2nx\pi(92)^2 10^{-12}}$$

Let $nx = 2N$, the total number of particles passed in a cylinder of one square centimeter cross section. Then

$$10 = 8e^{4N\pi(92)^2 10^{-12}}$$

Hence the number of particles in a vertical cylinder of one square centimeter cross section is given, roughly, by the equation

$$N = 34 \times 10^4$$

Temperature correction due to dust radiation.—With the number and size of the dust particles we are in position to determine at least an upper limit to the effect of the direct radiation of the particles themselves on the temperature of the earth.

The temperature of the dust particles obviously is very nearly that of the upper atmosphere in which they float and therefore, as we have seen, approximately $-55°$ C., or 218° C. absolute. As we have also seen, the quantity of radiation from the atmosphere below the isothermal region is substantially that which would be given off by a full radiator at 256° C. absolute.

Now assume the dust particles to be concentrated side by side on a common plane and further assume them to be full radiators—conditions that would raise their effect to the theoretical upper limit. Let E be the intensity or quantity per square centimeter of the outgoing planetary radiation, and D the intensity of the incoming dust radiation. Then

$$\text{E:D} = (256)^4 : a(218)^4,$$

in which a is the projected area of all the particles in a vertical cylinder of one square centimeter cross section.

But

$$a = 34\pi 10^4 (92)^2 10^{-12} = 9 \times 10^{-3}$$

Hence

$$\text{E} = 211\text{D}$$

Now, when the radiation D is absorbed by the lower atmosphere it follows that its temperature will be so increased that, when equilibrium is reached, the intensity of its new radiation will be to that of its old as 212 is to 211. Hence $\triangle T$, the effective temperature increase of the lower atmosphere, is given by the equation

$$\frac{(256+\triangle T)^4}{(256)^4}=\frac{212}{211}$$

from which

$$\triangle T = 0^\circ.3 \text{ C}$$

But, as stated above, the dust particles presumably are not full radiators, and therefore probably one-fifth of a degree C. is as great an increase in temperature as may reasonably be expected from this source. But this *increase*, 0°.2 C., is small in comparison with the *decrease*, 6° C. to 7° C., caused by the interception of solar radiation, already explained. Hence it appears reasonably certain that the sum total of all the temperature effects produced by volcanic dust in the upper atmosphere, must be, if long continued, a lowering of the surface temperature by several degrees C.

Total quantity of dust.—Let $nx = 2\ N$, the total number of particles passed in a cylinder of 1 square centimeter cross section. Then

$$10 = 8e^{4N\pi(92)^2 \times 10^{-12}}$$

Hence $N = 34 \times 10^4$, roughly, = number of particles in a vertical cylinder of 1 square centimeter cross section.

If A is the entire area of the earth in square centimeters, then the total number of dust particles is

$$NA = 1734 \times 10^{21}$$

But the radius of each particle is 92×10^{-6} cm. and its volume, assuming it spherical, 33×10^{-13} cubic centimeter. Hence the total volume of the dust, assuming the particles spherical, is equal, roughly, to a cube 179 meters, or about 587 feet on the side, an amount that certainly is not prohibitively large.

As just stated, the total quantity of dust sufficient, as we have seen, to cut down the intensity of the direct solar radiation by 20 per cent, and therefore, if indefinitely continued, capable, presumably, of producing an ice age, is astonishingly small—only the one hundred and seventy-fourth part of a cubic kilometer, or the seven hundred and twenty-seventh part of a cubic mile, even assuming that the particles are spherical. Since, however, in large measure the particles are more or less flat, as already explained, it follows that the actual total mass of the dust necessary and sufficient to reduce the intensity of direct solar radiation by 20 per cent probably is not more than the one thousand five hundredth part of a cubic mile, or the three hundred and fiftieth part of a cubic kilometer.

Hence even this small amount of solid material distributed once a year, or even once in two years, through the upper atmosphere would be more than sufficient to maintain continuously, or nearly so, the low temperature requisite to the production of an ice age, nor would it make any great difference where the volcanoes productive of the dust might be situated, since, from whatever point of introduction, the winds of the upper atmosphere would soon spread it more or less evenly over the entire earth.

A little calculation will show, too, that this quantity of dust yearly during a period of 100,000 years would produce a layer over the earth only about half a millimeter, or one-fiftieth of an inch, thick, and therefore one could hardly expect to find any marked accumulation of it, even if it had filled the atmosphere for much longer periods.

Inherent ability of the earth to produce its own climatic changes.—Whether periods of explosive volcanic activity, and in this case, since the locality of the volcano is a matter of small importance, the whole earth must be considered, occurred at such times as to synchronize with the ice ages and with other epochs of great climatic change is, of course, a problem for the geologist to solve. May it be that extensive upheavals and great volcanic activity were synchronous? If so, their climatic effects must have been additive. Increase in land elevation would, because of the resulting decrease in temperature, extend the area of snow and ice, and the snow in turn, through its power to reflect sunlight, would decrease the amount of solar energy actually absorbed, and thus still further extend the ice sheet, and so on through an indefinite though decreasing and limited series. Besides, an elevation of any considerable extent is pretty certain to be accompanied by increase in continental area and radical modification of shore lines, such that greater or less changes would follow in the direction, temperature, and magnitude of ocean currents, location, number and intensity of the permanent "highs" and permanent "lows," direction and force of local winds, amount of local precipitation, and a host of other meteorological phenomena. Thus, as the oceans and continents are now related to each other, the main drift of warm water from the tropics is toward the north and not toward the south, but a change in the relation of land and water that would reverse this proportion obviously would have the result of leaving the northern hemisphere, especially in higher latitudes, perceptibly colder than it now is, and of producing many other climatic changes, all of which it would be interesting to discuss from the standpoint of modern meteorology, though that would be beyond the restricted purpose of this paper—a consideration of the climatic effects of volcanic dust.

It is surmised, therefore, that the greatest of our past climatic changes may have been caused by the combined and roughly simul-

taneous variations in continental level and volcanic activity; cold periods coming with increase in elevation and increase in vulcanism, minor climatic oscillations with temporary changes in vulcanism, and warm periods when the land had gone back to low levels and volcanoes had ceased greatly to veil the skies with dust. But while great changes in level, such as probably have several times occurred, and great changes in vulcanism, such as also have occurred, would, even separately, produce climatic changes, it remains for the geologist to determine just what was the relation of these phenomena to each other and to the great climatic changes with which he is so deeply concerned.

However, this much appears well nigh certain: Since the beginning of reliable records, say 160 years ago, the average temperature of the earth has been perceptibly lower, possibly as much as 1° F., than it would have been if during all this time there had been no volcanic explosions violent enough to put dust into the isothermal region of the atmosphere. Similarly, on the other hand, if, during this period, violent volcanic explosions had been three or four times more numerous than they actually were, our average temperatures probably would have been at least 2° F. to 3° F. lower, or low enough, if long continued, to bring on at least a moderate ice age.

As already stated, it may be that our great climatic changes have been caused by corresponding changes in the output of solar energy, though at present this seems wholly impossible either definitely to prove or clearly to disprove; but, however they actually were produced, it is probable if not entirely certain that, given an invariable or nearly invariable solar constant, the earth itself possesses potentially the power of bringing about its own climatic changes—even of beginning and of ending its own ice ages.

Magnitude and importance of actual temperature changes.—The actual temperature range from sun-spot maximum to spot minimum varies roughly from 1° F. to 2° F., or possibly more, while the effect of volcanic dust appears to be fully as great—on rare occasions even much greater. In some ways, and in respect to many things, a range of average temperatures of 2° F. is well-nigh negligible, and therefore, however important the results may seem to the scientist, the ultra utilitarian would be justified in asking "What of it?"

Much of it, in a distinctly practical as well as in a purely scientific sense, as is true of every fact of nature. For instance, during the summer or growing season a change of 1° F. produces a latitude shift of the isotherms by fully 80 miles. Hence, if there is but little or no volcanic dust to interfere, during sun-spot minima cereals and other crops may successfully be grown 50 to 150 miles farther north (or south in the southern hemisphere) than at the times of spot

maxima. This alone is of great practical importance, especially to those who live near the thermal limits of crop production.

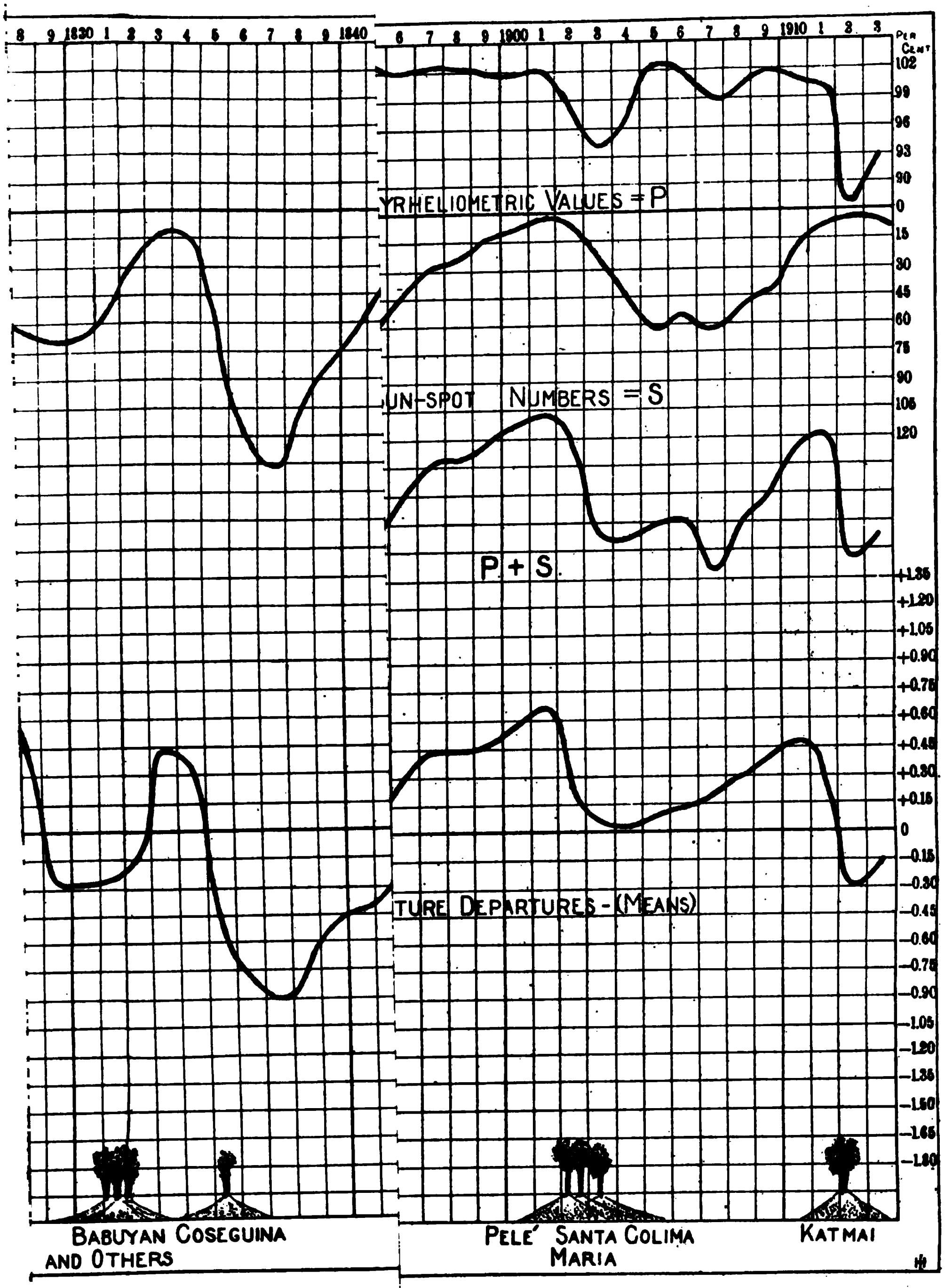
In addition to changing the area over which crop production is possible, a change of average temperature also affects, in some cases greatly, the time of plant development. Thus Walter [1] has shown that a change of only 1°.26 F. may alter, and in Mauritius has been observed actually to alter by as much as an entire year, the time required for the maturing of sugar cane. Hence the temperature changes that normally accompany sun-spot variations, though small in absolute magnitude, are of great importance, and, by availing ourselves of the reasonable foreknowledge we have of these changes, may easily be made of still greater importance.

In forecasting these small but important climatic changes it must be distinctly remembered that to the fairly periodic, and therefore predictable, sun-spot influence must be added the irregular and unpredictable volcanic effects. But even here the case is not bad for the forecaster, since the volcanic dust always produces, qualitatively, the same effect—a cooling—and since both the amount of this cooling and its duration may approximately be estimated from the nature of the volcanic explosion itself.

CONCLUSION.

It has been shown in the above, among many other things, that volcanic dust in the high atmosphere decreases the intensity of solar radiation in the lower atmosphere and therefore the average temperature of the earth, substantially as theory indicates *a priori* that it should; and this effect has been clearly traced back to 1750, or to the time of the earliest reliable records. Hence it is safe to say that such a relation between volcanic dust in the upper atmosphere and average temperatures of the lower atmosphere always has obtained, and therefore that volcanic dust must have been a factor, possibly a very important one, in the production of many, perhaps all, past climatic changes, and that through it, at least in part, the world is yet to know many another climatic change in an irregular but well-nigh endless series—usually slight though always important, but occasionally it may be, as in the past, both profound and disastrous.

[1] On the Influence of Forests on Rainfall and the Probable Effect of "Déboisement" on Agriculture in Mauritius (1908).



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U. S. DEPARTMENT OF AGRICULTURE

WEATHER BUREAU

CHARLES F. MARVIN, Chief

Vol. 6 Part 2

BULLETIN

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2. VERTICAL TEMPERATURE GRADIENTS BETWEEN MOUNT WEATHER, VA., AND VALLEY STATIONS.

By ALFRED J. HENRY.

[Dated September 11, 1913.]

There has recently become available additional comparative data of mean monthly temperatures at Mount Weather, Va., and valley stations.[1] These records make it possible to recompute the vertical temperature gradients between Mount Weather and valley stations.

For convenience of reference the mean monthly temperatures for Mount Weather, beginning with June, 1908, and the simultaneous differences between the means for Mount Weather and valley stations up to June, 1912, when the valley stations were closed, are given in the table below as suggested by Dr. J. v. Hann, Met. Zeit. Heft 7, 1913:

Simultaneous differences in monthly mean temperatures, Mount Weather, Va., and valley stations.

[Differences without sign are plus.]

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
Monthly mean temperatures, 1908, Mount Weather, Va.	.....	.....	.....	.....	.....	66.4	71.5	68.0	64.2	54.0	43.5	32.9
Simultaneous differences, 1908:												
Trapp, Va.	.....	.....	.....	.....	.....	3.2	1.7	2.9	2.3	3.8	2.8	3.2
Audley, Va.	.....	.....	.....	.....	.....	.....	3.0	2.6	−0.2	0.2	0.3	1.8
Monthly mean temperatures, 1909, Mount Weather, Va.	33.2	38.1	36.1	48.6	59.3	67.8	69.3	68.0	61.2	49.0	47.1	26.3
Simultaneous differences, 1909:												
Trapp, Va.	1.7	3.0	4.3	3.8	3.7	4.1	4.6	4.4	3.8	3.7	3.4	4.8
Benton's Farm, Va.	.....	.....	.....	3.9	3.0	3.1	3.0	2.6	1.7	−0.1	0.5	2.4
Audley, Va.	−0.5	2.5	3.4	2.8	2.2	2.7	2.8	2.6	2.7	0.8	1.0	2.9
Monthly mean temperatures, 1910, Mount Weather, Va.	29.0	29.3	48.0	52.3	56.2	63.9	72.0	67.7	65.5	55.4	35.8	25.2

[1] This Bulletin, *4*, p. 310.

3. A CHANGE IN SKYLIGHT POLARIZATION.

By Herbert H. Kimball.

[Mount Weather, Sept. 18, 1913.]

Observations made at the Mount Weather Observatory indicate that the polarization of skylight has undergone a decided change during the summer of 1913.

As shown in Tables 1 and 2,[1] the solar and the antisolar distances of the neutral points of Babinet and Arago, respectively, have increased markedly with the sun below the horizon, while changing but little with the sun above the horizon.

At the same time the increase in the polarization of skylight after sunset, at solar distance 90° and in the sun's vertical, which was so pronounced in 1902–3, and was also noticeable during the early months of the present year, has become quite insignificant, as is shown by the data in Table 3.

With the sun at zenith distance 60°, there has been a marked increase in the polarization of skylight at the point above designated, the average polarization for August, 1913, being 49 per cent, as compared with 32 per cent for August, 1912, and 44 per cent for July, 1913.

With the sun at this same zenith distance the intensity of direct solar radiation, which averaged about 10 per cent below the normal during the first seven months of 1913, was nearly up to its normal value in August.

It seems probable that these various changes are associated with the gradual precipitation from the atmosphere of the volcanic dust which has been present in its upper layers since the eruption of Katmai Volcano in June, 1912.

Table 1.—*Solar distance of Babinet's neutral point.*

Altitude of sun.	May–June, 1911.	Aug., 1911–June 8, 1912.	June 10, 1912–June, 1913.	Aug.–Sept., 1913.
°				
+2.0	....	....	27.3	....
1.5	....	....	25.7	....
1.0	....	....	....	....
+0.5	17.4	15.8	23.7	....
±0.0	16.8	15.4	19.5	21.2
−0.5	16.5	15.5	19.9	19.7
1.0	17.2	16.1	19.6	19.4
1.5	17.5	15.7	18.8	20.0
2.0	17.5	15.6	18.2	19.7
2.5	17.4	15.7	17.5	20.0
3.0	17.3	15.6	17.5	20.6
3.5	17.3	16.1	17.2	20.6
4.0	....	16.2	16.9	20.4
4.5	....	16.4	16.2	20.0
5.0	....	16.3	15.7	19.1
5.5	....	16.5	15.8	18.6
6.0	....	16.4	15.4	17.7
6.5	....	....	15.4	17.7
−7.0	....	....	15.5	18.2

[1] A recent test of the graduated circle on the polariscope used at Mount Weather showed that its zero was displaced so that all readings made previously were 1.3 degrees too high. The data for Mount Weather in Tables 5 and 6, p. 312, vol. 5, of this bulletin, are hereby corrected.

TABLE 2.—*Antisolar distance of Arago's neutral point.*

Altitude of sun.	May, 1911–June, 1912.	July 27, 1912.	Sept., 1912–June, 1913.	Aug.–Sept., 1913.
°				
+13			25.8	
12			26.1	
11			26.8	
10			26.7	
9.5			27.3	
9.0			27.0	
8.5				
8.0				24.1
7.5			24.6	24.2
7.0			25.3	24.3
6.5			25.8	24.4
6.0	19.7		25.8	24.4
5.5	20.3		26.4	24.7
5.0	20.1		25.7	24.6
4.5	20.1		25.6	24.3
4.0	19.5		25.8	24.2
3.5	18.8		25.4	24.4
3.0	18.7		25.4	24.4
2.5	18.5		25.1	23.8
2.0	18.6		24.6	23.5
1.5	18.6	21.7	23.8	23.4
1.0	18.4	21.7	23.3	23.2
+ 0.5	18.3	19.8	22.2	22.4
± 0.0	17.8	18.6	21.1	21.7
− 0.5	17.8	16.5	19.5	20.6
− 1.0	17.8	14.8	18.0	19.7
− 1.5	17.0	14.5	17.0	20.2
− 2.0	16.3	14.1	17.1	20.9
− 2.5	16.3	13.7	17.0	21.4
− 3.0	17.4	13.6	16.7	21.6
− 3.5	17.5	13.8	16.5	21.4
− 4.0		14.8	17.6	21.6
− 4.5		15.5	18.7	21.2
− 5.0		18.1	18.9	21.7
− 5.5			20.6	23.3
− 6.0				23.9
− 6.5				24.2

TABLE 3.—*Polarization of skylight after sunset, at solar distance 90° and in the sun's vertical.*

Time after sunset, minutes.	Asheville, N. C., Dec., 1902–Feb., 1903.	Washington, D. C., Nov. 29, 1909.	Mount Weather, Va., 1913.				
			Mar. 18.	Apr. 19.	Apr. 20.	Aug. 25.	Sept. 9.
0	36.6	74.9	52.9	48.5	41.8	55.2	59.9
2			59.8	50.6	46.2	57.3	
4		74.1		54.3		58.4	62.8
6			62.8	56.7	49.6	60.2	64.0
8		73.7	68.8	60.7	52.3	61.2	65.6
10	52.7			62.9	57.4	59.6	
12			67.7	64.7	62.0		63.2
14			70.9	66.9	65.4	61.1	59.7
16				64.7	66.7	60.4	
18				64.5		59.2	57.6
20	58.8			64.3	66.8		
22				64.3	67.4		
24							
26					67.8		
28							
29	60.9						

3. FREE-AIR DATA AT MOUNT WEATHER, VA., FOR JANUARY, FEBRUARY, AND MARCH, 1913.

By the Aerial Section, Wm. R. Blair in charge.

During this period 31 free-air observations were made, all by means of kites. Observations were made on every occasion that gave promise of a 24 or more hour series and on "international" days. On some occasions only one kite flight was possible, on others more. The mean of the highest altitudes reached in these flights is 2,670 meters above sea level.

Whenever three successive flights have been made, a chart of the free-air isotherms has been constructed. Two partial and two more complete series have been charted. Continuing the numbering of figures from the discussion of the last three months' data, figures 56 and 57 show the free-air isotherms observed January 17 and January 18, respectively. Figure 58 shows the free-air isotherms observed February 4 and 5, while in figures 59, 60, 61, and 62 the temperature, absolute humidity, wind direction and velocity, and the atmospheric electric potentials at levels 500 meters apart are charted. Figure 59 seems to show, in addition to the diurnal variation of temperature, fluctuations in this element with surface air pressure, which have taken place within the 24-hour period and for which satisfactory correction can not easily be made. Figures 59 to 62, therefore, show actual observations.

Figure 63 shows the free-air isotherms based upon observations made February 12 and 13. Figures 64 to 67 show the temperature, absolute humidity, wind direction and velocity, and the atmospheric electric potentials respectively at the different levels. This series did not extend beyond the 24 hours and no adequate correction for the 24-hour change can therefore be made. The data in these figures are, consequently, neither corrected nor smoothed.

The winter observations show a much smaller diurnal range of temperature than do those of other seasons. This smaller range together with the temperature effects accompanying the more rapid oscillation of the surface air pressure makes it more difficult to isolate the purely diurnal variation in temperature. It will be necessary therefore to rely on many observations made in this season or to study more carefully the relation between free-air temperature and surface air pressure. Series of observations extending over 24 or more hours are apparently hard to get in the winter season. The wind changes accompanying the passage of high and low pressure

areas are in most cases so frequent as to interrupt the series, though excellent opportunities for shorter series or for individual observations are frequent. The collection of sufficient winter data in complete series may therefore occupy several years. In the meantime a study of the relation between free-air temperature and surface pressure changes is in progress.

Immediately following, the separate observations of temperature, humidity, wind, and atmospheric electric potential are tabulated, together with notes on weather conditions. These tables and notes will be found of interest in any detailed study of the data charted. It may be noted, for example, that the base of the inversion of temperature observed in the early part of the February 12 and 13 series is conincident with the base of the St.-Cu. layer.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Jan. 17, 1913:													
First flight—	*mm.*	*C.*	%		*m. p. s.*	*m.*	*mm.*	*C.*	%	*g/cu. m.*		*m. p. s.*	*Volts.*
10.39 a. m.	718.0	14.5	50	ssw.	5.4	526	718.0	14.5	50	6.2	ssw.	5.4	......
10.51 a. m.	718.0	14.2	56	ssw.	4.9	1,080	672.3	13.3	54	6.2	w.	16.7	0
10.56 a. m.	718.0	13.6	61	ssw.	4.9	1,264	657.9	11.6	62	6.4	w.	19.8	170
10.57 a. m.	718.0	13.8	60	ssw.	4.9	1,632	629.8	12.7	47	5.2	w.	21.7	170
11.01 a. m.	718.0	14.5	54	ssw.	5.4	1,730	622.5	12.4	39	4.2	w.	21.7	170
11.18 a. m.	717.8	14.7	52	ssw.	5.8	2,566	562.7	5.6	60	4.2	wsw.	21.1	590
11.43 a. m.	717.6	13.7	61	ssw.	6.3	3,367	509.2	−2.6	84	3.3	wsw.	21.9	980
12.09 p. m.	717.4	14.3	60	ssw.	6.3	2,815	544.7	2.0	71	3.9	wsw.	22.6	700
12.21 p. m.	717.4	14.7	62	ssw.	5.8	2,581	560.8	4.3	59	3.8	wsw.	23.6	640
12.40 p. m.	717.2	14.5	66	s.	4.5	1,864	611.6	10.5	42	4.0	w.	23.0	310
12.51 p. m.	717.2	15.0	67	s.	4.0	1,619	629.8	10.5	69	6.6	w.	17.7	200
1.02 p. m.	717.1	15.2	58	s.	4.5	1,070	672.3	11.9	60	6.3	wsw.	12.4	0
1.07 p. m.	717.1	15.4	58	s.	4.5	526	717.1	15.4	58	7.6	s.	4.5	......
Second flight—													
1.43 p. m.	716.9	15.6	61	ssw.	4.5	526	716.9	15.6	61	8.0	ssw.	4.5	......
1.59 p. m.	716.8	15.9	57	ssw.	4.9	1,015	676.7	12.8	58	6.4	wsw.	12.4	0
2.17 p. m.	716.8	15.6	63	ssw.	4.9	1,717	622.0	8.0	80	6.6	w.	18.0	260
2.23 p. m.	716.8	15.8	61	ssw.	7.2	1,939	605.6	7.9	73	6.0	wsw.	21.1	400
2.24 p. m.	716.8	15.9	60	ssw.	7.2	2,086	594.9	7.3	63	4.9	wsw.	21.1	490
2.26 p. m.	716.8	16.0	59	ssw.	7.2	2,294	580.2	7.4	49	3.0	wsw.	27.3	680
2.33 p. m.	716.7	15.8	59	ssw.	6.3	2,579	560.3	5.0	47	3.2	wsw.	22.3	705
2.50 p. m.	716.7	15.8	59	ssw.	6.7	3,298	512.2	−1.2	56	2.5	wsw.	29.8	1,105
3.17 p. m.	716.8	15.4	65	ssw.	5.4	2,617	556.7	3.6	51	3.1	wsw.	29.0	640
3.34 p. m.	716.8	15.4	66	ssw.	6.3	2,347	575.6	3.8	71	4.4	wsw.	22.8	530
3.38 p. m.	716.8	15.4	66	s.	6.3	2,229	583.9	4.5	80	5.2	w.	22.2	480
3.40 p. m.	716.8	15.4	66	s.	6.3	2,103	593.0	4.3	88	5.7	w.	20.9	430
3.51 p. m.	716.9	15.4	66	s.	5.8	1,495	638.6	7.8	81	6.6	w.	10.8	0
4.06 p. m.	716.9	15.2	66	ssw.	6.7	916	684.6	12.0	64	6.8	sw.	10.5	0
4.12 p. m.	716.9	15.2	64	ssw.	6.7	526	716.9	15.2	64	8.2	ssw.	6.7	......

January 17, 1913.—First flight: Four kites were used; lifting surface, 25.2 sq. m. Wire out, 5,000 m.; at maximum altitude, 4,950 m.

Ci.-St., from the west-southwest, and St.-Cu., from the south-southwest, covered the sky.

At 8 a. m. pressure was high (772 mm.) off the middle Atlantic coast. Low pressure (742 mm.) was central over Lake Superior.

Second flight: Four kites were used; lifting surface, 25.2 sq. m. Wire out, 4,500 m., at maximum altitude.

The sky was covered with A.-St., from the west-southwest, and St. Cu. from the west.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Jan. 17, 1913:													
Third flight—	*mm.*	*C.*	%		*m. p. s.*	*m.*	*mm.*	*C.*	%	*g/cu.m.*		*m. p. s.*	*Volts.*
4.46 p. m.	717.0	14.6	63	ssw.	4.9	526	717.0	14.6	63	7.8	ssw.	4.9	......
4.57 p. m.	717.0	14.8	64	ssw.	4.5	833	691.5	14.3	62	7.6	sw.	8.3	0
5.20 p. m.	716.9	14.8	68	ssw.	5.8	1,123	668.0	11.2	65	6.5	wsw.	10.6	......
5.32 p. m.	716.9	14.6	73	ssw.	5.8	1,389	647.1	8.9	77	6.7	wsw.	9.9	170
5.59 p. m.	716.8	14.6	68	ssw.	5.8	1,749	619.4	5.6	93	6.5	wsw.	8.2	0
6.53 p. m.	717.2	14.5	66	wsw.	4.5	2,134	590.4	2.1	94	5.2	wsw.	10.7	0
7.07 p. m.	717.2	14.4	67	wnw.	3.6	1,262	656.5	5.3	87	6.0	wnw.	8.6	0
7.16 p. m.	717.3	14.3	65	nw.	3.1	526	717.3	14.3	65	7.9	nw.	3.1	......
Jan. 18, 1913:													
First flight—													
7.53 a. m.	714.2	11.8	80	ssw.	4.5	526	714.2	11.8	80	8.4	ssw.	4.5	......
7.59 a. m.	714.2	10.3	89	s.	3.6	768	693.8	12.1	65	6.9	w.	11.3	0
8.16 a. m.	714.1	10.2	87	s.	5.4	1,060	669.9	11.5	65	6.7	w.	9.6	0
8.24 a. m.	714.0	10.2	87	s.	5.8	1,618	626.3	6.2	76	5.6	w.	14.9	0
8.36 a. m.	713.9	10.6	85	s.	6.3	2,158	586.2	1.9	84	4.6	w.	15.5	260
8.41 a. m.	713.9	10.8	85	ssw.	5.8	2,537	559.0	− 1.1	84	3.7	w.	20.5	260
8.51 a. m.	713.8	10.5	86	ssw.	5.4	2,878	535.5	− 4.0	86	3.0	wsw.	....	490
8.52 a. m.	713.8	10.5	86	ssw.	5.4	3,066	523.0	− 3.5	76	2.8	wsw.	....	620
9.03 a. m.	713.7	10.2	88	ssw.	5.4	3,328	505.4	− 6.2	80	2.4	wsw.	21.6	......
9.10 a. m.	713.7	10.5	87	ssw.	4.9	3,060	523.0	− 4.2	76	2.6	wsw.	....	570
9.12 a. m.	713.7	10.6	86	ssw.	4.9	3,005	526.5	− 5.1	89	2.9	wsw.	....	530
9.24 a. m.	713.7	11.2	82	ssw.	5.4	2,636	551.8	− 2.2	87	3.5	wsw.	21.5	380
9.44 a. m.	713.7	11.5	79	s.	5.4	1,638	624.4	5.8	76	5.4	w.	16.1	0
10.00 a. m.	713.7	11.1	84	s.	6.3	1,032	671.8	10.0	69	6.4	wsw.	13.6	0
10.06 a. m.	713.7	11.2	82	ssw.	4.9	739	695.8	12.1	67	7.1	w.	11.8	0
10 08 a. m.	713.6	11.3	82	ssw.	4.9	526	713.6	11.3	82	8.3	ssw.	4.9	......
Second flight—													
10.39 a. m.	713.4	11.2	85	ssw.	6.3	526	713.4	11.2	85	8.6	ssw.	6.3	......
10.40 a. m.	713.4	11.2	85	ssw.	6.3	728	696.4	12.2	68	7.3	ssw.	....	 0
10.44 a. m.	713.3	11.2	85	ssw.	6.3	995	674.5	11.6	66	6.8	wsw.	13.2	0
11.03 a. m.	713.2	11.6	84	ssw.	6.3	1,720	618.0	6.2	82	6.0	wsw.	18.6	0
11.12 a. m.	713.2	11.6	82	ssw.	6.3	2,518	560.0	− 1.6	94	4.0	wsw.	21.9	540
11.27 a. m.	713.1	11.6	84	ssw.	7.6	2,987	527.6	− 4.3	88	3.0	wsw.	27.3	......
11.39 a. m.	713.1	11.8	82	ssw.	7.6	2,614	552.8	− 2.3	96	3.9	wsw.	24.6	......
11.51 a. m.	713.0	11.6	82	ssw.	7.2	2,333	572.6	0.6	96	4.8	w.	24.6	......
12.10 p. m.	712.8	11.7	82	ssw.	6.3	1,905	603.4	4.0	84	5.3	w.	29.0	......
12.22 p. m.	712.7	11.8	82	ssw.	5.4	1,590	627.1	5.8	82	5.8	w.	24.8	0
12.44 p. m.	712.3	12.2	82	ssw.	5.4	982	674.5	10.0	75	7.0	wsw.	19.2	0
12.52 p. m.	712.2	12.4	80	ssw.	5.8	526	712.2	12.4	80	8.7	ssw.	5.8	......

Third flight: Four kites were used; lifting surface, 25.2 sq. m. Wire out, 3,300 m.; at maximum altitude, 2,500 m.

There were 10/10 St.-Cu. from the west. After 7.10 p. m. there were occasional sprinkles of rain.

January 18, 1913—First flight: Four kites were used; lifting surface, 25.2 sq. m. Wire out, 4,500 m.; at maximum altitude, 4,300 m.

There were 10/10 A.-St. and St.-Cu. from the west-southwest.

Low pressure (755 mm.) was central over Lake Erie and high pressure (773 mm.) was central over the Bermudas.

Second flight: Three kites were used; lifting surface, 18.9 sq. m. Wire out, 4,000 m., at maximum altitude.

There were 10/10 A.-St. and St.-Cu. from the west-southwest. The head kite was in St.-Cu. at 11.13 and 11.39 a. m., altitude 2,500 m. Light rain fell from 11.50 a. m. to 12.28 p. m.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Jan. 18, 1913:													
Third flight—	*mm.*	*C.*	*%*		*m. p. s.*	*m.*	*mm.*	*C.*	*%*	*g/cu.m.*		*m. p. s.*	*Volts.*
1.25 p. m..	712.1	13.3	76	ssw.	5.8	526	712.1	13.3	76	8.7	ssw.	5.8	......
1.38 p. m..	712.0	13.4	69	ssw.	6.3	1,086	665.9	9.5	87	7.9	wsw.	20.5	0
1.54 p. m..	712.0	12.8	78	ssw.	6.3	1,735	615.3	3.1	98	5.8	wnw.	24.2	0
2.10 p. m..	712.0	13.0	77	ssw.	7.6	1,011	671.8	8.4	91	7.7	w.	18.0	0
2.18 p. m..	712.1	13.4	75	ssw.	7.2	526	712.1	13.4	75	8.6	ssw.	7.2	......
Fourth flight—													
2.52 p. m..	712.2	14.7	63	wsw.	12.1	526	712.2	14.7	63	7.9	wsw.	12.1	......
3.06 p. m..	712.2	15.1	61	wsw.	14.3	991	673.9	10.6	68	6.6	wsw.	19.2	0
3.30 p. m..	712.2	13.6	68	w.	17.9	1,686	619.2	3.1	81	4.8	w.	19.2	260
3.39 p. m..	712.3	14.7	53	w.	19.7	2,102	588.4	−0.3	77	3.6	w.	....	490
Feb. 4, 1913:													
First flight—													
9.57 a. m..	715.1	−2.6	78	nw.	8.9	526	715.1	− 2.6	78	3.1	nw.	8.9	......
10.07 a. m..	715.1	−2.4	79	nw.	9.4	941	678.4	− 7.5	79	2.1	wnw.	16.4	260
10.16 a. m..	715.2	−2.6	81	wnw.	8.0	1,437	636.3	−11.0	75	1.5	nw.	15.5	1,150
10.19 a. m..	715.2	−2.4	80	wnw.	7.2	1,555	626.6	−10.7	54	1.1	nw.	24.4	1,110
10.23 a. m..	715.3	−2.3	77	wnw.	6.7	1,595	623.4	−10.8	47	0.9	nw.	25.2	1,140
10.25 a. m..	715.3	−2.2	75	wnw.	7.6	1,739	612.0	−10.0	43	0.9	nw.	25.2	1,260
10.27 a. m..	715.3	−2.1	73	wnw.	7.6	1,844	603.6	−10.0	42	0.9	wnw.	22.7	1,340
10.29 a. m..	715.3	−2.0	72	wnw.	8.0	1,963	594.4	− 9.5	42	0.9	wnw.	22.7	1,440
10.34 a. m..	715.3	−1.9	73	wnw.	7.6	2,258	572.3	− 9.5	41	0.9	wnw.	28.6	1,435
10.36 a. m..	715.3	−1.9	73	wnw.	6.7	2,302	569.0	− 9.2	40	0.9	wnw.	30.2	1,430
10.50 a. m..	715.4	−1.6	71	wnw.	6.7	2,497	554.8	−10.1	37	0.8	wnw.	23.4	1,535
10.52 a. m..	715.4	−1.6	71	wnw.	6.7	2,577	549.1	−10.1	37	0.8	wnw.	23.4	1,580
10.55 a. m..	715.5	−1.5	70	wnw.	8.9	2,774	535,4	− 9.6	36	0.8	wnw.	22.6	1,670
11.10 a. m..	715.5	−1.8	71	wnw.	8.5	3,179	508.2	−10.4	32	0.7	wnw.	....	......
11.25 a. m..	715.5	−1.6	71	wnw.	7.6	2,765	536.2	− 9.5	31	0.7	wnw.	24.2	1,540
11.27 a. m..	715.5	−1.6	71	wnw.	7.8	2,661	543.6	− 9.5	31	0.7	wnw.	24.2	1,490
11.28 a. m..	715.5	−1.6	71	wnw.	7.8	2,650	544.4	− 9.7	31	0.7	wnw.	24.2	1,480
11.40 a. m..	715.6	−1.7	72	wnw.	4.5	2,265	572.3	− 8.6	31	0.7	wnw.	25.2	1,280
11.53 a. m..	715.6	−1.8	74	wnw.	4.5	1,890	600.5	− 8.6	31	0.7	wnw.	26.5	850
12.02 p. m..	715.6	−1.8	73	wnw.	4.5	1,471	634.0	−11.0	31	0.6	wnw.	12.6	330
12.13 p. m..	715.5	−1.6	71	nnw.	4.5	1,111	664.2	− 9.3	51	1.2	wnw.	9.9	......
12.18 p. m..	715.5	−1.6	71	nw.	3.6	526	715.5	− 1.6	71	3.0	nw.	3.6	......

Third flight: Two kites were used; lifting surface, 11.6 sq. m. Wire out, 1,800 m., at maximum altitude.

Before 1.50 p. m., there were 1/10 A.-St. and 9/10 St.-Cu. from the west-southwest; thereafter there were 10/10 to 8/10 St.-Cu. from the west. There was light rain from 1.52 to 2.10 p. m. The head kite was at the base of St.-Cu. at 1.49 p. m., altitude, 1,600 m.

Fourth flight: Four kites were used; lifting surface, 24.2 sq. m. Wire out, 3,700 m.; at maximum altitude, 3,500 m.

There were 7/10 A.-St., Ci.-St., and St.-Cu. from the west before 3 p. m.; thereafter there were 8/10 to 4/10 St.-Cu. from the west. The head kite was in St.-Cu. at 3.37 p. m., altitude about 2,000 m. There was light rain from 3.18 to 3.25 p. m.

February 4, 1913.—First flight: Four kites were used; lifting surface, 25.2 sq. m. Wire out, 5,000 m.; at maximum altitude, 4,800 m.

Ci., from the west, decreased from 5/10 to 3/10.

At 8 a. m., high pressure (781 mm.), central over eastern Montana, dominated conditions to the middle and southern Atlantic coasts. Low pressure (747 mm.) was central over Newfoundland.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Feb. 4, 1913:													
Second flight—	*mm.*	*C.*	%		*m. p. s.*	*m.*	*mm.*	*C.*	%	*g/cu.m.*		*m. p. s.*	*Volts.*
1.42 p. m. .	715.0	0.1	55	wnw.	8.9	526	715.0	0.1	55	2.7	wnw.	8.9	......
1.58 p. m. .	714.8	0.0	57	wnw.	9.8	941	678.8	− 0.2	55	2.6	wnw.	13.0	0
2.20 p. m. .	714.8	0.0	47	wnw.	10.3	1,608	623.9	− 6.1	47	1.4	wnw.	20.5	415
2.22 p. m. .	714.8	0.0	46	wnw.	11.6	1,717	615.4	− 5.1	47	1.5	wnw.	25.9	540
2.26 p. m. .	714.8	0.0	47	wnw.	12.1	1,874	603.1	− 5.0	47	1.5	wnw.	26.8	770
2.39 p. m. .	714.8	0.2	52	wnw.	8.9	2,278	573.0	− 5.5	45	1.4	nw.	22.9	1,170
2.51 p. m. .	714.8	0.1	44	wnw.	10.3	2,697	543.0	− 8.9	44	1.0	nw.	24.2	1,410
2.54 p. m. .	714.8	0.0	46	wnw.	8.9	2,919	527.7	− 9.5	43	1.0	nw.	26.9	1,540
2.55 p. m. .	714.8	0.0	46	wnw.	8.9	3,015	521.1	− 9.1	43	1.0	nw.	30.6	1,600
2.57 p. m. .	714.8	−0.1	48	wnw.	8.9	3,157	511.8	− 9.1	44	1.0	wnw.	31.9	1,685
2.58 p. m. .	714.8	−0.1	48	wnw.	8.9	3,218	507.1	− 9.5	45	1.0	wnw.	31.9	......
3.01 p. m. .	714.8	−0.2	50	wnw.	9.4	3,070	516.5	− 9.3	44	1.0	wnw.	29.8	1,685
3.02 p. m. .	714.8	−0.2	50	wnw.	9.1	2,959	523.8	−10.7	43	0.9	wnw.	....	1,685
3.17 p. m. .	714.8	−0.4	52	wnw.	10.3	2,931	525.7	−10.1	40	0.9	wnw.	29.2	1,670
3.20 p. m. .	714.8	−0.4	52	wnw.	11.2	2,902	527.7	− 9.1	40	0.9	wnw.	29.2	1,650
3.27 p. m. .	714.8	−0.5	53	wnw.	10.7	2,859	530.5	− 9.1	40	0.9	nw.	27.9	1,620
3.30 p. m. .	714.8	−0.5	53	wnw.	10.7	2,792	535.2	− 9.7	40	0.9	nw.	27.9	1,560
3.34 p. m. .	714.9	−0.6	54	wnw.	10.3	2,750	538.1	− 9.2	39	0.9	nw.	26.7	1,530
3.35 p. m. .	714.9	−0.6	54	wnw.	9.8	2,724	540.0	− 9.4	38	0.9	nw.	26.7	1,505
3.58 p. m. .	714.9	−0.8	53	wnw.	8.9	2,104	584.9	− 6.9	38	1.1	nw.	27.5	1,010
4.04 p. m. .	714.9	−0.9	52	wnw.	8.0	1,902	600.1	− 7.9	40	1.0	nw.	27.3	855
4.05 p. m. .	714.9	−0.9	51	wnw.	7.8	1,837	605.1	− 7.3	42	1.1	nw.	27.3	805
4.17 p. m. .	715.0	−0.9	48	wnw.	7.8	1,573	626.1	− 6.8	44	1.2	nw.	22.9	615
4.19 p. m. .	715.0	−0.9	48	wnw.	7.8	1,519	630.4	− 7.5	45	1.2	nw.	20.5	580
4.28 p. m. .	715.1	−0.9	47	wnw.	7.2	983	675.1	− 4.6	46	1.5	wnw.	13.6	0
4.40 p. m. .	715.2	−1.1	45	wnw.	5.8	526	715.2	− 1.1	45	2.0	wnw.	5.8	......
Third flight—													
5.20 p. m. . .	715.3	−1.6	48	wnw.	4.0	526	715.3	− 1.6	48	2.0	wnw.	4.0	......
5.35 p. m. . .	715.3	−1.6	48	wnw.	4.5	1,002	673.7	− 3.1	50	1.9	wnw.	12.1	0
5.50 p. m. . .	715.3	−1.8	47	wnw.	4.9	1,357	644.1	− 5.5	51	1.6	w.	12.4	330
6.02 p. m. . .	715.3	−2.1	49	wnw.	4.9	1,692	616.9	− 7.4	54	1.4	wnw.	16.7	540
6.30 p. m. . .	715.4	−2.2	55	wnw.	5.4	2,455	559.2	− 9.9	48	1.0	wnw.	....	1,390
6.40 p. m. . .	715.4	−2.5	57	wnw.	4.2	3,095	517.3	− 9.1	48	1.1	wnw.	....	1,890
6.57 p. m. . .	715.5	−2.5	56	wnw.	6.3	3,199	508.0	− 9.9	52	1.1	wnw.	....	2,040
7.22 p. m. . .	715.5	−2.6	57	wnw.	8.5	2,875	529.5	− 9.1	52	1.2	wnw.	....	1,780
7.25 p. m. . .	715.5	−2.6	57	wnw.	8.5	2,832	532.4	− 9.3	52	1.2	wnw.	....	1,740
7.31 p. m. . .	715.4	−2.6	58	wnw.	8.5	2,591	549.1	− 8.6	53	1.3	wnw.	....	1,545
7.34 p. m. . .	715.4	−2.6	58	wnw.	10.3	2,549	554.1	− 9.0	53	1.2	wnw.	....	1,510
7.46 p. m. . .	715.4	−2.6	58	wnw.	11.6	2,219	576.2	− 9.3	44	1.0	wnw.	23.6	1,260
7.55 p. m. . .	715.4	−2.7	56	wnw.	9.8	1,756	611.6	− 7.9	48	1.2	wnw.	21.7	770
7.58 p. m. . .	715.4	−2.7	56	wnw.	9.8	1,621	622.3	− 8.2	50	1.2	wnw.	20.5	615
8.19 p. m. . .	715.3	−2.8	57	w.	10.7	999	673.7	− 5.1	54	1.7	w.	18.0	0
8.25 p. m. . .	715.2	−2.7	56	w.	10.7	526	715.2	− 2.7	56	2.2	w.	10.7	......

Second flight: Three kites were used; lifting surface, 18.9 sq. m. Wire out, 4,500 m.; at maximum altitude, 4,250 m.

A.-Cu. and St.-Cu., from the west, increased from 2/10 to 5/10 before 3.45 p. m.; thereafter the St.-Cu. disappeared. At the end of the flight there were 3/10 A.-Cu.

Third flight: Four kites were used; lifting surface, 25.2 sq. m. Wire out, 4,500 m.; at maximum altitude, 4,450 m.

1/10 A.-Cu., from the west, disappeared before 6.45 p. m.; thereafter the sky was cloudless.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Feb. 4, 1913:													
Fourth flight—	*mm.*	*C.*	*%*		*m. p. s.*	*m.*	*mm.*	*C.*	*%*	*g/cu.m.*		*m. p. s.*	*Volts.*
9.03 p. m.	715.0	−2.8	57	wnw.	11.2	526	715.0	− 2.8	57	2.2	wnw.	11.2	......
9.12 p. m.	715.0	−3.0	57	wnw.	8.9	1,086	666.1	− 4.8	54	1.8	wnw.	16.7	0
9.25 p. m.	715.0	−3.1	57	w.	8.5	1,758	611.4	− 7.8	54	1.4	w.	19.8	950
9.30 p. m.	715.0	−3.2	58	w.	7.6	1,994	593.1	− 8.6	52	1.3	w.	21.7	1,220
9.31 p. m.	715.0	−3.3	59	w.	7.6	2,048	589.0	− 7.8	52	1.3	w.	20.5	1,290
9.35 p. m.	715.0	−3.4	60	w.	5.4	2,274	572.1	− 8.7	52	1.2	w.	18.6	1,550
9.38 p. m.	715.0	−3.4	60	w.	7.6	2,550	552.0	− 8.6	52	1.3	w.	24.2	1,630
9.41 p. m.	715.0	−3.4	60	w.	7.6	2,690	542.1	− 9.3	52	1.2	w.	26.8	1,740
9.43 p. m.	715.0	−3.4	60	w.	7.6	2,801	534.3	− 9.5	52	1.2	w.	26.8	1,870
9.45 p. m.	715.0	−3.4	60	w.	7.6	2,885	528.6	−10.1	54	1.2	w.	26.8	1,960
9.49 p. m.	715.0	−3.4	60	w.	6.9	3,080	515.4	−10.0	54	1.2	w.	....	2,190
9.55 p. m.	715.0	−3.4	60	w.	6.3	3,468	489.2	−14.0	55	0.8	w.	....	2,555
10.15 p. m.	715.0	−3.3	58	w.	5.1	3,255	502.3	−13.6	57	0.9	w.	....	2,320
10.38 p. m.	715.0	−3.3	58	w.	7.6	2,809	532.3	−11.7	59	1.1	wnw.	....	1,760
10.42 p. m.	715.0	−3.3	58	w.	7.6	2,728	538.0	−12.2	59	1.0	wnw.	....	1,685
10.44 p. m.	715.0	−3.2	57	w.	8.0	2,684	541.1	−11.8	59	1.1	wnw.	....	1,670
10.53 p. m.	715.0	−3.2	57	w.	9.4	2,476	556.0	−11.2	59	1.1	wnw.	23.0	1,500
10.56 p. m.	715.0	−3.2	57	w.	9.4	2,391	562.1	−12.2	59	1.0	wnw.	23.0	1,430
10.58 p. m.	715.0	−3.2	57	w.	9.4	2,259	572.1	−11.6	59	1.1	w.	23.0	1,320
11.00 p. m.	715.0	−3.2	57	w.	9.8	2,139	581.0	−11.8	58	1.1	w.	23.3	1,220
11.08 p. m.	714.9	−3.2	56	w.	8.9	1,784	608.3	−10.1	56	1.2	w.	24.2	1,015
11.19 p. m.	714.9	−3.1	55	w.	9.8	1,519	629.7	−10.2	56	1.2	w.	20.7	640
11.33 p. m.	714.8	−3.0	48	w.	9.4	1,053	668.5	− 6.8	57	1.6	w.	16.1	0
11.42 p. m.	714.7	−3.3	54	w.	9.8	526	714.7	− 3.3	54	2.0	w.	9.8	......
Fifth flight—													
12.14 a. m.	714.5	−3.1	53	w.	10.7	526	714.5	− 3.1	53	2.0	w.	10.7	......
12.26 a. m.	714.4	−3.2	54	w.	9.4	1,071	666.7	− 5.3	53	1.7	w.	15.5	0
12.45 a. m.	714.3	−3.5	54	w.	8.9	1,657	618.4	− 8.8	58	1.4	w.	22.2	920
12.46 a. m.	714.3	−3.5	54	w.	8.9	1,788	607.9	− 8.5	58	1.4	w.	22.2	1,100
12.51 a. m.	714.3	−3.5	54	w.	8.9	2,012	590.6	− 9.5	58	1.3	w.	22.8	1,360
12.54 a. m.	714.2	−3.4	54	w.	8.9	2,141	580.7	− 9.1	58	1.3	wnw.	24.6	1,520
1.06 a. m.	714.2	−3.8	57	w.	7.2	2,525	552.6	− 9.5	59	1.3	wnw.	25.0	2,240
1.13 a. m.	714.2	−4.0	56	w.	8.5	2,928	524.4	−12.1	61	1.1	wnw.	26.6	3,620
1.17 a. m.	714.2	−4.0	55	w.	8.5	3,064	515.1	−11.5	59	1.1	wnw.	30.6	4,060
1.22 a. m.	714.2	−4.1	54	w.	9.4	3,101	512.2	−11.5	59	1.1	wnw.	29.8	4,200
1.34 a. m.	714.1	−4.0	52	w.	10.7	3,038	516.0	−11.9	61	1.1	wnw.	29.0	3,900
1.46 a. m.	714.1	−4.0	51	w.	11.2	2,471	555.6	−10.7	61	1.2	wnw.	29.0	2,420
1.57 a. m.	714.1	−4.1	51	w.	8.0	2,372	562.7	−10.3	61	1.3	wnw.	27.7	2,150
2.02 a. m.	714.1	−4.1	50	w.	8.7	2,347	564.6	−11.2	61	1.2	wnw.	26.5	2,100
2.18 a. m.	714.0	−4.1	55	w.	10.3	2,105	582.6	−11.5	61	1.2	wnw.	28.8	1,660
2.36 a. m.	713.9	−3.9	53	w.	11.2	1,658	617.4	− 9.7	66	1.5	wnw.	27.5	1,280
2.42 a. m.	713.9	−3.9	53	w.	9.4	1,591	622.7	−10.3	68	1.4	wnw.	29.8	1,310
2.50 a. m.	713.8	−4.1	55	w.	9.4	1,459	633.4	− 9.8	69	1.5	wnw.	28.6	1,080
3.05 a. m.	713.8	−4.0	52	w.	11.2	1,033	669.1	− 7.3	65	1.7	wnw.	24.2	330
3.14 a. m.	713.8	−4.0	52	w.	13.4	526	713.8	− 4.0	52	1.8	w.	13.4	......

Fourth flight: Four kites were used; lifting surface, 25.2 sq. m. Wire out, 5,000 m., at maximum altitude.

The sky was cloudless.

Fifth flight: Four kites were used; lifting surface, 25.2 sq. m. Wire out, 5,000 m. at maximum altitude.

The sky was cloudless.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Feb. 4, 1913:													
Sixth flight—	*mm.*	*C.*	*%*		*m. p. s.*	*m.*	*mm.*	*C.*	*%*	*g/cu.m.*		*m. p. s.*	*Volts.*
3.45 a. m.	713.6	−4.0	55	w.	13.9	526	713.6	− 4.0	55	1.9	w.	13.9	......
3.55 a. m.	713.6	−4.3	54	w.	12.5	1,111	662.3	− 6.5	61	1.7	wnw.	20.5	615
4.04 a. m.	713.6	−4.1	55	w.	13.4	1,633	619.4	−10.5	68	1.4	wnw.	24.2	1,735
4.10 a. m.	713.6	−4.4	58	w.	13.9	1,699	614.0	−10.1	70	1.5	wnw.	29.8	1,685
4.14 a. m.	713.5	−4.3	57	w.	14.3	1,765	608.7	−11.0	70	1.4	wnw.	29.9	1,940
4.15 a. m.	713.5	−4.3	56	w.	14.3	1,870	600.4	−11.6	70	1.3	wnw.	29.9	2,390
4.16 a. m.	713.5	−4.3	56	w.	14.3	1,895	598.4	−11.0	69	1.4	wnw.	29.9	2,520
4.37 a. m.	713.4	−4.3	57	w.	17.0	2,425	558.3	−11.7	54	1.0	wnw.	33.1	4,280
4.43 a. m.	713.4	−4.4	58	w.	18.8	2,675	540.2	−13.2	57	0.9	wnw.	31.0	......
4.55 a. m.	713.3	−4.5	58	w.	17.9	2,444	556.3	−12.3	54	1.0	wnw.	....	3,630
5.04 a. m.	713.3	−4.6	60	w.	18.8	2,280	568.3	−12.2	52	0.9	wnw.	....	3,360
5.06 a. m.	713.3	−4.6	60	w.	21.5	2,215	573.3	−12.5	53	0.9	wnw.	....	3,260
5.11 a. m.	713.3	−4.6	61	w.	19.7	2,016	588.3	−12.0	55	1.0	wnw.	....	2,940
5.40 a. m.	713.4	−5.1	65	w.	23.2	1,621	619.4	−10.5	55	1.1	wnw.	....	2,290
5.43 a. m.	713.4	−5.1	65	w.	17.9	1,569	623.7	−11.0	55	1.1	wnw.	....	2,200
6.00 a. m.	713.4	−5.3	65	w.	17.9	1,407	636.8	−11.2	63	1.2	wnw.	....	1,800
6.17 a. m.	713.5	−5.1	62	w.	23.2	936	677.0	− 8.1	60	1.5	wnw.	24.2	460
6.32 a. m.	713.6	−5.3	65	w.	17.9	526	713.6	− 5.3	65	2.1	w.	17.9	......
Seventh flight—													
7.05 a. m.	713.8	−5.6	60	wnw.	16.1	526	713.8	− 5.6	60	1.9	wnw.	16.1	......
7.15 a. m.	714.0	−5.8	62	wnw.	14.3	1,096	663.7	− 8.7	65	1.6	wnw.	24.2	755
7.25 a. m.	714.1	−5.9	64	wnw.	11.6	1,656	617.3	−11.4	66	1.3	wnw.	24.5	1,640
7.26 a. m.	714.1	−5.9	64	wnw.	8.5	1,709	613.0	−12.7	68	1.2	wnw.	26.0	1,640
7.29 a. m.	714.2	−5.8	66	wnw.	8.9	1,777	607.7	−12.2	68	1.2	wnw.	26.0	1,640
7.32 a. m.	714.2	−5.9	68	wnw.	9.8	1,881	599.4	−12.9	68	1.1	wnw.	26.2	1,810
7.53 a. m.	714.5	−6.4	69	wnw.	10.7	2,360	563.3	−12.7	55	0.9	wnw.	....	2,740
7.54 a. m.	714.5	−6.5	70	wnw.	11.6	2,442	557.3	−13.3	53	0.9	wnw.	29.7	2,860
7.55 a. m.	714.5	−6.5	70	wnw.	11.6	2,595	546.2	−12.4	52	0.9	wnw.	32.2	3,090
8.02 a. m.	714.6	−6.6	73	wnw.	8.9	2,862	527.5	−12.8	49	0.8	wnw.	29.8	3,460
8.03 a. m.	714.6	−6.6	73	wnw.	8.9	2,668	541.1	−12.6	48	0.8	wnw.	....	5,050
8.05 a. m.	714.6	−6.6	74	wnw.	8.9	2,624	544.2	−12.8	47	0.8	wnw.	....	5,000
8.38 a. m.	714.9	−6.3	69	wnw.	10.7	2,393	561.3	−11.6	33	0.6	wnw.	....	3,500
8.40 a. m.	714.9	−6.3	68	wnw.	12.5	2,351	564.3	−11.8	33	0.6	wnw.	....	3,220
8.42 a. m.	715.0	−6.3	67	wnw.	12.5	2,325	566.3	−11.5	32	0.6	wnw.	....	3,020
9.03 a. m.	715.1	−5.8	64	wnw.	13.4	2,021	589.3	−11.7	31	0.6	wnw.	....	2,120
9.15 a. m.	715.1	−5.2	57	wnw.	13.4	1,585	623.8	−12.3	46	0.8	wnw.	....	1,470
9.40 a. m.	715.1	−5.4	56	wnw.	13.9	1,022	671.1	− 8.7	55	1.3	wnw.	....	425
9.49 a. m.	715.1	−5.2	56	wnw.	13.9	526	715.1	− 5.2	56	1.8	wnw.	13.9	......

Sixth flight: Three kites were used; lifting surface, 17.9 sq. m. Wire out, 5,000 m., at maximum altitude.

The sky was cloudless until 5.40 a. m., except at 3.55 a. m. when a few St.-Cu. were observed on the northeastern horizon. After 5.40 a. m. there were a few St.-Cu. from the west.

Seventh flight: Four kites were used; lifting surface, 23.2 sq. m. Wire out, 5,000 m., at maximum altitude.

St.-Cu., from the west-northwest, varied from a few to 2/10.

At 8 a. m. high pressure (777 mm.) central over northwestern Montana dominated conditions east of the Mississippi River. Low pressure (753 mm.) was central over the lower St. Lawrence Valley.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Feb. 4, 1913:													
Eighth flight—	*mm.*	*C.*	*%*		*m. p. s.*	*m.*	*mm.*	*C.*	*%*	*g/cu.m.*		*m. p. s.*	*Volts.*
10.21 a.m..	715.2	−5.0	54	wnw.	15.6	526	715.2	− 5.0	54	1.8	wnw.	15.6	......
10.35 a.m..	715.3	−4.8	56	wnw.	10.3	954	677.3	− 7.7	60	1.6	wnw.	16.2	480
10.54 a.m..	715.5	−4.3	45	wnw.	7.6	1,641	619.7	−13.2	52	0.8	wnw.	20.0	980
10.55 a.m..	715.5	−4.3	45	wnw.	7.6	1,721	613.3	−12.6	54	0.9	wnw.	25.0	1,050
10.57 a.m..	715.5	−4.2	45	wnw.	7.6	1,775	609.0	−13.1	52	0.9	wnw.	27.4	1,110
10.59 a.m..	715.5	−4.2	44	wnw.	10.3	1,904	598.7	−11.9	49	0.9	wnw.	27.4	1,230
11.13 a.m..	715.5	−4.4	49	nw.	8.0	2,685	540.5	−13.2	36	0.6	wnw.	31.4	1,740
11.16 a.m..	715.5	−4.4	50	nw.	6.7	2,712	538.6	−12.7	34	0.6	wnw.	30.1	1,750
11.20 a.m..	715.5	−4.4	52	nw.	8.5	2,852	528.8	−13.0	32	0.5	wnw.	30.1	1,880
11.24 a.m..	715.5	−4.4	53	nw.	8.0	3,020	517.4	−12.9	30	0.5	nw.	28.9	2,040
11.36 a.m..	715.4	−4.0	50	nw.	6.7	3,385	493.2	−13.5	26	0.4	nw.	....	......
11.42 a.m..	715.4	−4.2	50	nw.	6.7	3,222	504.4	−13.6	25	0.4	nw.	....	2,210
12.13 p.m..	715.3	−3.6	47	nw.	8.0	2,818	531.7	−11.2	20	0.4	nw.	27.5	1,500
12.22 p.m..	715.3	−3.6	48	wnw.	9.4	2,718	538.6	−11.4	20	0.4	nw.	24.8	1,400
12.39 p.m..	715.2	−3.4	52	nw.	9.8	1,679	616.5	−10.1	19	0.4	wnw.	18.0	590
12.42 p.m..	715.2	−3.3	50	nw.	8.9	1,559	626.2	−11.3	19	0.4	wnw.	18.6	590
12.51 p.m..	715.1	−3.4	49	wnw.	10.3	1,360	642.6	−10.5	23	0.5	wnw.	17.2	......
1.01 p.m..	715.1	−3.3	50	wnw.	11.6	923	679.8	− 7.8	32	0.8	wnw.	10.8	......
1.08 p.m..	715.0	−3.2	48	wnw.	8.9	526	715.0	− 3.2	48	1.8	wnw.	8.9	......
Ninth flight—													
1.40 p.m..	714.8	−2.9	46	nw.	9.8	526	714.8	−2.9	46	1.8	nw.	9.8	......
1.54 p.m..	714.7	−2.6	49	nw.	8.5	981	674.6	−6.3	47	1.4	nw.	11.0	......
2.05 p.m..	714.7	−2.2	46	nw.	5.8	1,240	652.7	−7.6	49	1.3	nw.	14.7	......
2.14 p.m..	714.7	−2.3	48	nw.	8.5	526	714.7	−2.3	48	1.9	nw.	8.5	......
Feb. 6, 1913:													
First flight—													
8.15 a.m..	712.1	−10.0	67	nw.	18.8	526	712.1	−10.0	67	1.4	nw.	18.8	......
8.19 a.m..	712.1	−10.0	67	nw.	17.0	795	687.4	−10.4	59	1.2	nw.	24.2	640
8.33 a.m..	712.1	− 9.9	65	nw.	14.8	1,224	650.4	−10.4	58	1.2	nw.	....	1,375
8.44 a.m..	712.1	− 9.8	67	nw.	17.4	1,471	629.9	−11.8	53	1.0	nw.	....	1,850
8.49 a.m..	712.1	− 9.7	68	nw.	20.6	1,552	623.3	−10.2	47	1.0	nw.	....	2,270
8.55 a.m..	712.1	− 9.6	68	nw.	17.9	1,793	604.1	−10.4	45	0.9	nw.	....	3,500
8.59 a.m..	712.1	− 9.4	69	nw.	16.5	1,551	623.3	−10.3	46	1.0	nw.	....	3,100
9.03 a.m..	712.1	− 9.3	66	nw.	16.5	1,470	629.9	−10.9	44	0.9	nw.	....	2,710
9.34 a.m..	712.4	− 9.0	56	nw.	12.1	970	672.4	−10.9	45	0.9	nw.	23.0	490
9.39 a.m..	712.5	− 8.7	57	nw.	13.0	945	674.9	−11.5	47	0.9	nw.	22.9	510
9.41 a.m..	712.5	− 8.6	57	nw.	13.4	887	679.9	−10.9	49	1.0	nw.	21.7	450
9.43 a.m..	712.5	− 8.6	57	nw.	12.5	832	684.9	−10.9	52	1.0	nw.	18.6	380
9.48 a.m..	712.6	− 8.6	57	nw.	12.5	526	712.6	− 8.6	57	1.4	nw.	12.5	......

Eighth flight: Four kites were used; lifting surface, 23.2 sq. m. Wire out, 5,000 m.; at maximum altitude.

There were a few St.-Cu. from the west-northwest.

Ninth flight: Two kites were used; lifting surface, 12.6 sq. m. Wire out, 1,300 m.; at maximum altitude, 1,200 m.

The sky was cloudless.

February 6, 1913.—First flight: Three kites were used; lifting surface, 16.9 sq. m. Wire out, 3,000 m., at maximum altitude.

The sky was cloudless.

At 8 a. m. high pressure (782 mm.), central over British Columbia, dominated conditions east of the Mississippi River. Pressure was low over Maine (755 mm.) and over Newfoundland (748 mm.).

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Feb. 6, 1913:	*mm.*	*C.*	*%*		*m. p. s.*	*m.*	*mm.*	*C.*	*%*	*g/cu. m.*		*m. p. s.*	*Volts.*
Second flight—													
10.26 a. m.	712.8	−7.8	49	nw.	10.7	526	712.8	− 7.8	49	1.3	nw.	10.7	......
10.35 a. m.	712.8	−7.6	49	nw.	10.3	838	684.8	− 9.0	55	1.3	nw.	......	170
10.48 a. m.	712.9	−7.6	49	nw.	9.8	1,223	651.4	−11.8	57	1.1	wnw.	12.4	1,150
11.04 a. m.	712.9	−7.5	46	nw.	11.2	1,673	614.2	−13.2	57	0.9	wnw.	13.6	......
11.38 a. m.	712.7	−7.2	45	nw.	13.9	......	......	......	......	......	wnw.	......	......
11.58 a. m.	712.6	......	......	nw.	13.9	526	712.6	......	......	......	nw.	13.9	......
Feb. 7, 1913:													
First flight—													
8.49 a. m.	716.0	−9.2	......	w.	5.4	526	716.0	− 9.2	......	......	w.	5.4	......
9.12 a. m.	716.0	−7.7	46	w.	5.4	807	690.4	−13.7	41	0.6	wnw.	15.1	440
9.27 a. m.	716.0	−7.8	45	w.	5.4	1,001	672.8	−15.4	42	0.6	wnw.	11.5	880
10.01 a. m.	715.9	−7.8	48	wnw.	6.3	1,734	610.0	−20.9	49	0.4	nw.	21.1	2,120
10.03 a. m.	715.9	−7.7	49	wnw.	5.4	2,015	587.5	−17.7	47	0.5	nw.	21.6	2,860
10.10 a. m.	715.9	−7.4	48	wnw.	6.3	2,073	582.8	−19.2	42	0.4	nw.	......	......
10.30 a. m.	715.9	−6.8	43	w.	8.0	2,075	582.8	−20.3	38	0.3	wnw.	......	......
10.47 a. m.	715.9	−6.5	38	w.	10.3	1,868	599.7	−17.1	35	0.4	wnw.	......	2,400
10.53 a. m.	715.9	−6.4	37	w.	11.6	1,551	625.5	−19.3	36	0.3	wnw.	......	1,300
10.57 a. m.	715.9	−6.3	39	wsw.	11.6	1,537	626.6	−15.6	36	0.5	wnw.	......	1,200
11.00 a. m.	715.9	−6.3	40	wsw.	11.2	1,487	630.8	−19.4	36	0.3	wnw.	......	1,090
11.15 a. m.	715.8	−5.7	29	w.	14.8	818	689.3	−12.8	41	0.7	w.	11.8	40
11.24 a. m.	715.7	−6.0	34	w.	8.5	526	715.7	− 6.0	34	1.0	w.	8.5	......
Second flight—													
12.02 p. m.	715.4	−5.2	37	w.	8.9	526	715.4	− 5.2	37	1.2	w.	8.9	......
12.10 p. m.	715.3	−4.9	36	w.	13.0	885	683.1	−10.8	35	0.7	wnw.	11.0	0
1.04 p. m.	714.7	−4.3	38	w.	8.5	1,164	658.0	−13.7	40	0.6	w.	9.2	......
1.10 p. m.	714.6	−4.2	36	w.	9.8	928	678.7	−10.6	41	0.8	w.	......	......
1.15 p. m.	714.4	−4.2	36	wnw.	8.9	526	715.4	− 4.2	36	1.2	wnw.	8.9	......
Feb. 8, 1913:													
8.23 a. m.	713.4	−6.2	38	w.	10.7	526	713.4	− 6.2	38	1.1	w.	10.7	......
8.34 a. m.	713.4	−5.8	35	w.	8.0	921	678.1	− 8.9	33	0.8	w.	16.8	0
8.43 a. m.	713.4	−5.8	35	w.	10.3	1,148	658.5	− 9.8	36	0.8	wnw.	20.5	720
8.45 a. m.	713.4	−5.8	35	w.	10.3	1,289	646.6	− 6.9	36	1.0	wnw.	20.5	1,160
8.47 a. m.	713.3	−5.8	35	w.	8.0	1,407	636.9	− 7.3	37	1.0	wnw.	19.9	1,550
8.50 a. m.	713.3	−5.8	35	w.	8.0	1,445	633.8	− 5.5	37	1.2	wnw.	21.8	1,550
8.55 a. m.	713.3	−5.8	35	w.	7.6	1,524	627.4	− 6.0	37	1.1	wnw.	21.7	1,750
9.02 a. m.	713.3	−5.8	35	w.	7.6	1,941	595.0	− 3.2	35	1.3	wnw.	19.1	2,895
9.30 a. m.	713.1	−5.4	40	w.	7.6	2,852	529.5	− 9.3	25	0.6	wnw.	22.7	4,550
10.13 a. m.	712.9	−4.5	29	w.	8.9	3,620	478.5	−14.5	15	0.2	wnw.	26.0	......
10.51 a. m.	712.8	−3.8	34	w.	9.8	3,075	513.7	−11.4	14	0.3	wnw.	24.4	4,350
11.12 a. m.	712.8	−3.6	34	w.	11.2	2,093	582.8	− 3.3	16	0.6	wnw.	21.0	1,830
11.28 a. m.	712.8	−3.2	31	wsw.	8.9	1,598	621.0	−12.6	30	0.5	wnw.	21.0	1,550
11.42 a. m.	712.7	−3.0	32	w.	11.6	1,044	667.2	− 7.8	38	1.0	wnw.	21.0	490
11.54 a. m.	712.7	−2.9	30	w.	10.7	526	712.7	− 2.9	30	1.2	w.	10.7	......

Second flight: Three kites were used; lifting surface, 17.0 sq. m. Wire out, 4,900 m.; at maximum altitude, 1,400 m.

The sky was cloudless.

February 7, 1913.—First flight: Three kites were used; lifting surface, 18.9 sq. m. Wire out, 3,000 m.; at maximum altitude, 2,470 m.

The sky was cloudless until 10.03 a. m. Thereafter there were a few St.-Cu. from the northwest.

At 8 a. m. a ridge of high pressure (778 mm.) central over Wyoming extended from British Columbia to the Louisiana coast. Low pressure (754 mm.) was central over Ontario.

Second flight: Two kites were used; lifting surface, 10.7 sq. m. Wire out, 1,300 m.; at maximum altitude, 1,000 m.

There were a few St.-Cu. from the west.

February 8, 1913.—Five kites were used; lifting surface, 29.6 sq. m. Wire out, 7,000 m. at maximum altitude.

There were 9/10 A.-St. from the west.

High pressure (774 mm.) was central over Texas; low pressure (751 mm.) was central over Quebec.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Feb. 12, 1913:													
First flight—	*mm.*	*C.*	*%*		*m. p. s.*	*m.*	*mm.*	*C.*	*%*	*g/cu.m.*		*m. p. s.*	*Volts.*
1.14 p. m...	714.7	− 5.8	44	nw.	13.9	526	714.7	− 5.8	44	1.3	nw.	13.9	......
1.25 p. m...	714.7	− 5.6	43	nw.	17.4	906	680.5	−11.6	45	0.8	nw.	16.0	640
1.41 p. m...	714.7	− 5.8	55	nw.	17.9	1,315	644.8	−16.5	58	0.7	nw.	13.0	1,170
1.53 p. m...	714.7	− 5.0	38	nw.	17.0	1,804	603.9	−21.5	66	0.5	wnw.	20.9	2,070
1.57 p. m...	714.7	− 5.4	40	nw.	16.1	2,031	585.7	−22.7	58	0.4	wnw.	20.2	2,320
2.00 p. m...	714.7	− 6.0	43	nw.	14.3	2,179	573.8	−21.5	48	0.4	nw.	27.0	2,405
2.08 p. m...	714.8	− 5.9	49	nw.	14.3	2,654	538.3	−21.2	26	0.2	nw.	33.9	3,200
2.12 p. m...	714.8	− 5.9	52	nw.	16.5	2,863	523.3	−19.8	24	0.2	nw.	33.1	......
2.54 p. m...	715.2	− 6.2	54	nw.	17.9	1,954	....	−22.3	12	0.1	nw.	18.0	1,830
3.12 p. m...	715.5	− 6.0	40	nw.	15.6	1,622	619.5	−20.5	32	0.3	nw.	16.9	1,340
3.24 p. m...	715.6	− 6.4	41	nw.	16.5	1,124	662.1	−15.3	51	0.7	nw.	12.9	810
3.38 p. m...	715.8	− 6.3	51	nw.	13.4	880	683.8	−12.2	48	0.9	nw.	15.1	0
3.50 p. m...	716.0	− 6.6	52	nw.	13.9	526	716.0	− 6.6	52	1.5	nw.	13.9	......
Second flight—													
4.23 p. m...	716.4	− 7.1	48	nw.	17.4	526	716.4	− 7.1	48	1.3	nw.	17.4	......
4.28 p. m...	716.4	− 7.1	48	nw.	17.4	959	677.4	−12.3	46	0.8	nw.	16.0	425
4.48 p. m...	716.7	− 7.6	49	nw.	17.4	1,447	635.2	−18.2	65	0.7	nw.	16.2	1,315
4.55 p. m...	716.7	− 7.6	49	nw.	15.2	1,722	612.1	−21.1	67	0.5	nw.	20.9	1,930
4.58 p. m...	716.8	− 7.6	49	nw.	17.4	1,948	593.7	−21.7	60	0.5	nw.	21.8	2,210
4.59 p. m...	716.8	− 7.6	49	nw.	17.9	2,011	588.6	−21.0	53	0.4	nw.	23.5	2,210
5.05 p. m...	716.9	− 7.8	49	nw.	15.6	2,101	581.6	−21.2	37	0.3	nw.	19.3	2,210
5.07 p. m...	716.9	− 7.8	50	nw.	17.4	2,139	578.7	−20.4	35	0.3	nw.	20.6	2,340
5.08 p. m...	717.0	− 7.9	50	nw.	14.3	2,164	576.7	−21.0	32	0.3	nw.	21.5	2,420
5.10 p. m...	717.0	− 7.9	51	nw.	15.6	2,330	563.9	−20.4	30	0.3	nw.	22.3	2,990
5.15 p. m...	717.1	− 8.0	53	nw.	13.4	2,787	530.0	−21.8	25	0.2	nw.	26.5	4,540
5.26 p. m...	717.3	− 8.2	50	nw.	13.0	2,865	524.7	−20.6	20	0.2	nw.	29.0	4,800
5.36 p. m...	717.5	− 8.5	55	nw.	13.4	2,882	523.1	−22.3	16	0.1	nw.	29.4	......
6.04 p. m...	718.1	− 9.5	65	nw.	15.2	2,202	573.7	−20.9	13	0.1	nw.	19.3	3,400
6.06 p. m...	718.1	− 9.5	64	nw.	15.2	2,164	576.7	−21.5	12	0.1	nw.	21.0	3,480
6.08 p. m...	718.2	− 9.5	61	nw.	13.0	2,153	577.7	−20.6	12	0.1	nw.	21.0	3,500
6.10 p. m...	718.2	− 9.5	58	nw.	13.0	2,153	577.7	−20.2	12	0.1	nw.	22.1	3,500
6.26 p. m...	718.6	− 9.6	59	nw.	17.4	1,790	607.0	−22.2	19	0.1	nw.	18.1	2,350
6.37 p. m...	718.8	− 9.7	55	nw.	14.8	1,459	635.2	−20.9	43	0.4	nw.	18.5	1,595
6.53 p. m...	719.1	−10.2	59	nw.	11.2	970	678.4	−16.0	64	0.8	nw.	14.4	730
7.02 p. m...	719.3	−10.4	66	nw.	10.3	526	719.3	−10.4	66	1.4	nw.	10.3	......

February 12, 1913.—First flight: Four kites were used; lifting surface, 23.3 sq. m. Wire out, 4,500 m.; at maximum altitude, 4,300 m.

There were 1/10 St.-Cu., from the west-northwest; altitude, about 1,800 m.

At 8 a. m. high pressure (778 mm.) was central over Iowa; low pressure (742 mm.) was central over Newfoundland.

Second flight: Four kites were used; lifting surface, 24.3 sq. m. Wire out, 5,000 m.; at maximum altitude, 4,500.

There were a few to 1/10 St.-Cu. from the northwest; altitude, about 1,950 m.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Feb. 12, 1913:													
Third flight—	*mm.*	*C.*	%		*m. p. s.*	*m.*	*mm.*	*C.*	%	*g/cu.m.*		*m. p. s.*	*Volts.*
7.36 p. m.	719.7	−10.7	48	nw.	10.3	526	719.7	−10.7	48	1.0	nw.	10.3	......
7.46 p. m.	719.8	−10.9	50	nw.	14.3	925	683.1	−15.7	64	0.8	nw.	17.7	780
8.03 p. m.	719.9	−11.1	57	nw.	14.3	1,377	643.1	−21.0	78	0.6	nw.	17.4	2,230
8.05 p. m.	719.9	−11.2	59	nw.	16.5	1,386	642.1	−21.2	77	0.6	nw.	18.7	2,270
8.13 p. m.	720.0	−11.4	67	nw.	17.0	1,685	616.8	−19.7	45	0.4	nw.	19.5	4,000
8.17 p. m.	720.0	−11.4	64	nw.	17.0	1,783	608.6	−19.8	39	0.4	nw.	17.6	3,860
8.18 p. m.	720.0	−11.4	63	nw.	17.4	1,833	604.5	−19.1	36	0.4	nw.	17.6	3,800
8.20 p. m.	720.0	−11.4	64	nw.	14.8	1,858	602.5	−19.7	34	0.3	nw.	18.1	3,820
8.22 p. m.	720.0	−11.5	65	nw.	15.6	1,973	593.3	−18.8	33	0.3	nw.	16.8	3,890
8.36 p. m.	720.1	−11.6	59	nw.	13.4	2,755	534.7	−21.2	23	0.2	nw.	20.3	5,400
8.52 p. m.	720.2	−11.8	74	nw.	11.6	3,289	496.4	−22.0	16	0.1	nw.	....	7,000
9.02 p. m.	720.3	−11.9	64	nw.	15.2	3,099	508.9	−22.1	15	0.1	nw.	....	6,390
9.28 p. m.	720.8	−12.2	53	nw.	16.1	2,320	565.7	−19.3	14	0.1	nw.	15.0	4,450
9.32 p. m.	720.8	−12.2	53	nw.	13.0	2,144	579.4	−20.7	13	0.1	nw.	16.0	4,100
9.46 p. m.	721.1	−12.2	55	nw.	7.6	1,997	591.3	−22.8	14	0.1	nw.	16.7	3,740
9.48 p. m.	721.1	−12.3	55	nw.	9.8	1,936	596.3	−23.7	15	0.9	nw.	16.7	3,480
9.51 p. m.	721.2	−12.3	56	nw.	8.0	1,751	611.7	−23.3	16	0.1	nw.	16.2	2,700
9.53 p. m.	721.2	−12.3	57	nw.	8.5	1,652	620.0	−23.5	19	0.1	nw.	16.7	2,280
10.00 p. m.	721.3	−12.3	57	nw.	8.5	1,409	641.0	−22.6	43	0.3	nw.	12.2	1,830
10.15 p. m.	721.4	−12.4	57	nw.	13.9	926	684.2	−18.1	63	0.7	nw.	13.3	480
10.25 p. m.	721.4	−12.4	57	nw.	13.4	526	721.4	−12.4	57	1.0	nw.	13.4	......
Fourth flight—													
10.58 p. m.	721.6	−12.9	64	nw.	10.3	526	721.6	−12.9	64	1.1	nw.	10.3	......
11.08 p. m.	721.7	−13.0	63	nw.	13.4	903	686.6	−16.9	65	0.8	nw.	13.0	425
11.17 p. m.	721.8	−13.0	59	nw.	14.8	1,171	662.7	−19.7	69	0.6	nw.	19.1	1,630
11.22 p. m.	721.9	−13.0	59	nw.	14.3	1,353	646.6	−18.4	53	0.6	nw.	17.6	2,210
11.27 p. m.	722.0	−13.0	60	nw.	14.8	1,430	640.1	−17.2	45	0.5	nw.	14.4	2,320
11.33 p. m.	722.0	−13.0	62	nw.	14.3	1,806	608.8	−18.1	38	0.4	nw.	13.6	3,710
11.37 p. m.	722.1	−13.0	63	nw.	12.1	2,022	591.5	−17.5	35	0.4	nw.	14.8	4,520
11.50 p. m.	722.3	−13.2	59	nw.	9.4	2,403	562.1	−19.2	27	0.3	nw.	14.7	5,100
Feb. 13, 1913:													
12.08 a. m.	722.5	−13.3	58	nw.	10.3	2,956	521.9	−22.4	24	0.2	nw.	20.6	6,880
12.12 a. m.	722.5	−13.3	58	nw.	12.1	3,321	496.6	−21.9	21	0.2	nw.	23.5	8,410
12.13 a. m.	722.5	−13.3	59	nw.	12.1	3,416	490.1	−21.4	21	0.2	nw.	21.8	8,350
12.16 a. m.	722.5	−13.4	60	nw.	15.6	3,495	485.2	−21.5	20	0.2	nw.	27.7	8,300
12.38 a. m.	722.7	−13.5	70	nw.	10.7	3,009	518.4	−21.0	17	0.1	nw.	....	6,700
12.42 a. m.	722.7	−13.5	70	nw.	14.3	2,906	525.3	−21.2	17	0.1	nw.	21.5	6,360
1.00 a. m.	722.8	−13.5	70	nw.	11.6	2,372	565.0	−18.2	17	0.2	nw.	14.7	4,700
1.11 a. m.	722.9	−13.6	67	nw.	16.5	1,762	612.9	−15.4	17	0.2	nw.	11.9	3,180
1.17 a. m.	722.9	−13.6	65	nw.	10.7	1,541	633.7	−17.2	17	0.2	nw.	16.8	2,555
1.25 a. m.	723.0	−13.6	64	nw.	9.8	1,486	635.9	−19.3	18	0.2	nw.	19.0	2,440
1.28 a. m.	723.0	−13.6	63	nw.	6.3	1,373	645.5	−19.0	19	0.2	nw.	19.0	2,100
1.30 a. m.	723.0	−13.7	62	nw.	6.3	1,204	660.5	−20.3	21	0.2	nw.	14.8	1,580
1.34 a. m.	723.0	−13.7	61	nw.	5.4	1,022	676.8	−19.2	32	0.3	nw.	12.6	1,010
1.48 a. m.	723.1	−13.8	61	nw.	7.6	526	723.1	−13.8	61	0.9	nw.	7.6	......

Third flight: Five kites were used; lifting surface, 30.6 sq. m. Wire out, 5,200 m., at maximum altitude.

There were a few St.-Cu. from the northwest.

Fourth flight: Five kites were used; lifting surface, 31.5 sq. m. Wire out, 5,200 m. at maximum altitude.

The sky was cloudless.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Feb. 13, 1913:													
Fifth flight—	*mm.*	*C.*	%		*m. p. s.*	*m.*	*mm.*	*C.*	%	*g/cu.m.*		*m. p. s.*	*Volts.*
2.35 a. m..	723.2	−14.0	73	nw.	7.6	526	723.2	−14.0	73	1.1	nw.	7.6	......
2.45 a. m..	723.2	−14.0	73	nw.	8.5	925	685.8	−18.8	81	0.8	nw.	11.3	1,010
2.50 a. m..	723.2	−14.0	67	nw.	8.5	1,008	678.2	−20.1	81	0.7	nw.	14.9	1,640
2.55 a. m..	723.2	−14.0	64	nw.	10.3	1,446	639.5	−17.6	65	0.7	nw.	13.0	3,640
2.57 a. m..	723.2	−14.0	64	nw.	8.0	1,433	640.6	−18.0	57	0.6	nw.	13.9	3,600
3.02 a. m..	723.2	−14.1	70	nw.	9.4	1,522	633.1	−15.7	49	0.6	nw.	14.3	3,880
3.15 a. m..	723.2	−14.2	73	nw.	13.4	2,168	581.1	−16.4	37	0.5	nw.	14.8	4,900
3.18 a. m..	723.2	−14.3	73	nw.	14.3	2,483	557.1	−17.5	35	0.4	nw.	17.8	6,260
3.20 a. m..	723.2	−14.3	73	nw.	11.2	2,753	537.4	−17.4	34	0.4	nw.	16.5	7,400
3.35 a. m..	723.1	−14.3	75	nw.	8.5	3,131	510.8	−19.3	30	0.3	nw.	20.0	7,420
3.40 a. m..	723.1	−14.4	76	nw.	9.8	3,423	491.0	−18.7	28	0.3	nw.	22.5	8,480
3.47 a. m..	723.1	−14.4	77	nw.	11.6	3,692	474.6	−19.3	25	0.2	nw.	....	......
3.54 a. m..	723.1	−14.4	77	nw.	13.9	3,642	478.6	−19.7	25	0.2	nw.	....	8,600
4.18 a. m..	723.0	−14.4	73	nw.	17.0	3,354	497.4	−19.2	22	0.2	nw.	22.1	6,000
4.22 a. m..	723.0	−14.4	73	nw.	17.9	3,267	503.3	−20.1	22	0.2	nw.	18.5	5,430
4.37 a. m..	723.0	−14.4	73	nw.	19.2	2,215	579.1	−14.3	21	0.3	nw.	9.0	1,930
4.47 a. m..	722.9	−14.4	74	nw.	17.0	1,230	658.7	−10.9	22	0.4	nw.	11.2	1,090
4.57 a. m..	722.9	−14.5	76	nw.	19.2	1,008	678.2	−15.0	21	0.3	nw.	19.5	920
4.58 a. m..	722.9	−14.5	76	nw.	17.9	995	679.3	−16.0	22	0.3	nw.	18.7	910
5.02 a. m..	722.9	−14.5	76	nw.	18.9	875	690.2	−17.2	27	0.3	nw.	15.3	810
5.06 a. m..	723.0	−14.6	74	nw.	21.5	889	689.1	−14.8	30	0.4	nw.	21.0	830
5.10 a. m..	723.0	−14.6	73	nw.	24.6	815	695.8	−16.5	35	0.4	nw.	16.8	0
5.21 a. m..	723.2	−14.7	77	nw.	17.0	526	723.2	−14.7	77	1.1	nw.	17.0	......
Sixth flight—													
5.57 a. m..	723.7	−14.7	77	nw.	10.7	526	723.7	−14.7	77	1.1	nw.	10.7	......
6.06 a. m..	723.8	−14.8	77	nw.	15.2	913	687.5	−17.7	83	0.9	nw.	17.5	1,350
6.12 a. m..	723.9	−14.7	72	nw.	13.4	1,510	635.7	− 9.8	57	1.2	nw.	14.4	2,555
7.33 a. m..	724.6	−14.8	70	nw.	5.4	1,874	606.7	−13.1	32	0.5	nw.	4.1	......
7.54 a. m..	724.6	−14.6	72	nw.	10.3	1,568	631.5	− 9.1	28	0.6	nw.	5.7	1,970
8.08 a. m..	724.6	−14.3	63	nw.	8.5	1,042	676.6	−17.7	28	0.3	nw.	12.6	1,230
8.19 a. m..	724.7	−14.2	68	wnw.	9.8	526	724.7	−14.2	68	1.0	wnw.	9.8	......
Seventh flight—													
8.47 a. m..	724.8	−13.5	53	wnw.	11.2	526	724.8	−13.5	53	0.8	wnw.	11.2	......
8.51 a. m..	724.8	−13.4	58	wnw.	10.7	679	710.4	−15.6	56	0.7	wnw.	12.3	950
8.53 a. m..	724.8	−13.4	61	wnw.	13.0	833	696.0	−12.9	47	0.8	wnw.	12.6	900
9.03 a. m..	724.8	−13.3	74	wnw.	8.0	954	685.1	−14.5	34	0.5	wnw.	12.8	900
9.23 a. m..	724.9	−12.5	55	wnw.	10.3	1,051	676.4	−12.3	23	0.4	wnw.	4.8	1,510
9.42 a. m..	724.9	−12.2	46	wnw.	11.2	1,150	667.8	−14.1	17	0.3	wnw.	7.3	1,560
9.48 a. m..	725.0	−11.8	40	wnw.	8.9	1,489	639.0	−10.5	17	0.4	wnw.	5.5	1,685
9.51 a. m..	725.0	−11.8	46	wnw.	6.3	1,563	632.8	−11.2	17	0.3	wnw.	5.5	......
9.54 a m..	725.0	−11.8	52	wnw.	6.7	1,666	624.5	− 9.7	16	0.4	wnw.	5.5	......
10.04 a. m..	725.0	−11.7	58	w.	4.0	1,618	628.5	− 9.6	14	0.3	wnw.	3.7	......
10.08 a. m..	725.0	−11.7	54	w.	4.0	1,515	636.9	−11.8	13	0.2	wnw.	6.1	......
10.12 a. m..	724.9	−11.6	51	w.	4.9	1,575	631.8	−10.6	11	0.2	wnw.	7.8	......
10.17 a. m..	724.9	−11.5	49	w.	5.8	1,165	666.7	−12.5	11	0.2	wnw.	7.0	......
10.23 a. m..	724.9	−11.2	52	w.	5.4	860	693.8	−14.2	10	0.1	wnw.	6.5	......
10.27 a. m..	724.9	−11.0	47	w.	5.8	921	688.4	−13.1	11	0.2	wnw	7.6	0
10.30 a. m..	724.8	−10.8	42	w.	4.0	932	687.3	−14.5	11	0.2	wnw.	6.8	0
10.34 a. m..	724.8	−10.6	38	w.	4.0	526	724.8	−10.6	38	0.8	w.	4.0	......

Fifth flight: Five kites were used; lifting surface, 31.5 sq. m. Wire out, 5,200 m., at maximum altitude.

The sky was cloudless.

Sixth flight: Six kites were used; lifting surface, 37.8 sq. m. Wire out, 5,500 m.; at maximum altitude, 3,600 m.

The sky was cloudless. Light haze extended around and 10 degrees above the horizon after 7.56 a. m.

At 8 a. m. high pressure (777 mm.) was central over West Virginia and covered the eastern half of the United States.

Seventh flight: Five kites were used; lifting surface, 33.5 sq. m. Wire out, 3,000 m. at maximum altitude.

The sky was cloudless until 10.15 a. m., when a few Ci., from the west, appeared. Light haze extended around and 10 degrees above the horizon.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Mar. 5, 1913:	*mm.*	*C.*	%		*m. p. s.*	*m.*	*mm.*	*C.*	%	*g/cu.m.*		*m. p. s.*	*Volts*
9.09 a. m.	713.9	1.8	77	nw.	22.4	526	713.9	1.8	77	4.2	nw.	22.4	......
9.18 a. m.	713.8	1.5	72	nw.	20.6	974	674.9	−2.0	59	2.4	nw.	18.6	0
9.21 a. m.	713.8	1.6	71	nw.	19.7	1,211	655.1	−2.4	57	2.3	nw.	....	530
9.25 a. m.	713.8	1.8	68	nw.	20.6	1,476	633.8	−0.4	46	2.2	nw.	14.9	950
9.31 a. m.	713.7	2.1	67	nw.	17.0	1,517	630.5	−1.2	37	1.6	nw.	....	1,030
9.37 a. m.	713.7	2.6	64	nw.	14.8	1,560	627.2	−0.2	35	1.7	nw.	....	1,170
9.46 a. m.	713.6	2.0	68	nw.	13.4	2,117	584.8	−3.2	30	1.1	nw.	....	1,170
10.12 a. m.	713.5	2.3	66	nw.	9.8	2,334	568.6	−5.2	26	0.8	nw.	....	1,205
11.15 a. m.	713.5	3.5	59	wnw.	7.6	2,167	580.7	−3.4	17	0.6	nw.	....	......
11.20 a. m.	713.5	3.5	59	wnw.	7.6	1,918	599.1	−4.0	17	0.6	nw.	....	......
11.41 a. m.	713.5	3.2	60	nw.	8.0	1,889	601.3	−3.4	16	0.6	nw.	....	......
11.47 a. m.	713.5	3.6	61	nw.	8.0	1,587	624.9	−4.8	16	0.5	nw.	....	......
11.51 a. m.	713.5	3.5	62	nw.	8.9	1,503	631.6	−4.2	16	0.6	nw.	....	......
12.03 p. m.	713.5	3.8	56	nw.	7.2	526	713.5	3.8	56	3.5	nw.	7.2	......
Mar. 6, 1913:													
8.27 a. m.	705.8	1.1	60	w.	6.7	526	705.8	1.1	60	3.1	w.	6.7	......
8.38 a. m.	705.9	1.3	62	w.	8.9	996	665.7	−1.3	67	2.9	wnw.	16.8	0
8.50 a. m.	706.0	1.1	62	w.	12.5	1,581	618.2	−8.3	82	2.0	w.	17.6	780
9.05 a. m.	706.2	1.1	62	w.	17.9	2,329	560.7	−15.4	94	1.3	w.	17.6	1,685
9.20 a. m.	706.5	−1.2	88	wnw.	23.7	2,767	528.3	−20.1	98	0.9	wnw.	....	2,555
9.25 a. m.	706.6	−1.8	90	wnw.	22.4	2,437	551.7	−17.5	98	1.1	wnw.	....	2,555
9.35 a. m.	706.9	−2.1	88	wnw.	21.5	2,037	581.8	−14.3	100	1.5	wnw.	....	2,200
9.45 a. m.	707.1	−2.0	82	nw.	22.4	1,814	599.3	−13.2	100	1.6	wnw.	....	1,890
9.55 a. m.	707.3	−1.8	78	nw.	19.7	1,498	624.7	−10.4	100	2.1	wnw.	....	1,460
11.17 a. m.	707.7	−1.6	48	nw.	25.0	526	707.7	−1.6	48	2.0	nw.	25.0	......

March 5, 1913.—Six kites were used; lifting surface, 34.9 sq. m. Wire out, 5,400 m.; at maximum altitude, 3,300 m.

There were 5/10 to few St.-Cu. from the northwest, altitude 1,200 m., before 11 a. m.; thereafter the sky was cloudless.

High pressure (767 mm.) was central over western Tennessee. Low pressure was central over Nantucket (757 mm.) and over Lake Superior (752 mm.).

March 6, 1913.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 5,000 m. at maximum altitude.

Before 9 a. m. there were 8/10 to 9/10 St.-Cu. from the west, altitude, 1,800 m. From 9.14 to 9.35 a. m. a snow squall occurred with 10/10 St.-Cu. from the west-northwest, altitude, about 1,350 m. Thereafter 10/10 St.-Cu. from the west-northwest, altitude, 2,000 m., decreased to 3/10. The head kite was hidden by St.-Cu. from 9.05 to 9.43 a. m.

Low pressure (748 mm.) was central over western Quebec and high pressure (773 mm.) was central over Iowa.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Mar. 19, 1913:	*mm.*	*C.*	%		*m. p. s.*	*m.*	*mm.*	*C.*	%	*g/cu.m.*		*m. p. s.*	*Volts.*
1.44 p. m...	723.9	13.8	56	se.	11.6	526	723.9	13.8	56	6.6	se.	11.6	......
2.02 p. m...	723.7	13.9	55	se.	11.6	1,018	682.4	8.4	71	6.0	s.	10.2	0
2.12 p. m...	723.6	14.4	54	se.	10.3	1,361	654.4	4.2	80	5.1	s.	14.3	0
2.16 p. m...	723.5	14.2	56	se.	10.7	1,508	642.6	2.1	80	4.5	s.	14.3	110
2.17 p. m...	723.5	14.2	56	se.	10.7	1,562	638.4	3.6	82	5.1	s.	12.6	170
2.23 p. m...	723.5	13.7	60	se.	10.3	1,706	626.9	2.7	45	2.6	s.	10.9	170
2.28 p. m...	723.4	14.1	61	se.	12.5	1,732	624.9	3.2	47	2.8	s.	8.6	210
2.32 p. m...	723.4	14.4	62	se.	13.9	1,761	622.8	2.1	50	2.8	s.	8.6	250
2.35 p. m...	723.4	14.7	63	se.	13.9	1,775	621.8	3.5	45	2.8	s.	6.7	260
2.38 p. m...	723.3	14.2	65	se.	13.9	1,879	613.6	1.8	44	2.4	s.	6.7	260
3.57 p. m...	722.8	13.6	57	se.	10.3	2,181	590.5	−0.4	45	2.1	s.	6.1	0
4.02 p. m...	722.8	13.8	57	se.	10.3	2,330	579.7	−4.9	......	......	s.	8.8	0
4.04 p. m...	722.8	14.1	56	se.	11.2	2,293	582.5	−5.4	88	2.8	s.	8.8	0
4.05 p. m...	722.7	14.2	56	se.	11.2	2,306	581.5	−2.5	58	2.3	s.	......	0
4.08 p. m...	722.7	14.0	57	se.	10.7	2,316	580.6	−4.7	65	2.2	s.	......	0
4.10 p. m...	722.7	13.8	58	se.	10.7	2,336	578.7	−2.3	54	2.2	s.	......	0
4.11 p. m...	722.7	13.8	58	se.	11.2	2,315	579.7	−4.5	......	......	s.	11.6	0
4.15 p. m...	722.6	13.8	58	se.	9.8	2,169	590.5	−4.5	82	2.8	s.	11.2	0
4.29 p. m...	722.5	13.7	58	se.	8.9	1,599	634.2	−0.2	100	4.8	s.	10.9	0
4.45 p. m...	722.3	13.7	58	se.	7.2	935	687.8	8.6	76	6.5	s.	8.3	0
4.52 p. m...	722.2	13.6	59	se.	7.2	526	722.2	13.6	59	6.9	se.	7.2	......

March 19, 1913.—Six kites were used; lifting surface, 37.8 sq. m. Wire out, 6,000 m.; at maximum altitude, 2,900 m.

Cloudiness varied from 7/10 to 3/10 St.-Cu. from the south. The head kite was in St.-Cu., altitude 1,400 m., from 4 to 4.13 p. m. and again at 4.29 p. m.

High pressure (777 mm.) central off the immediate New York coast covered the eastern half of the United States.

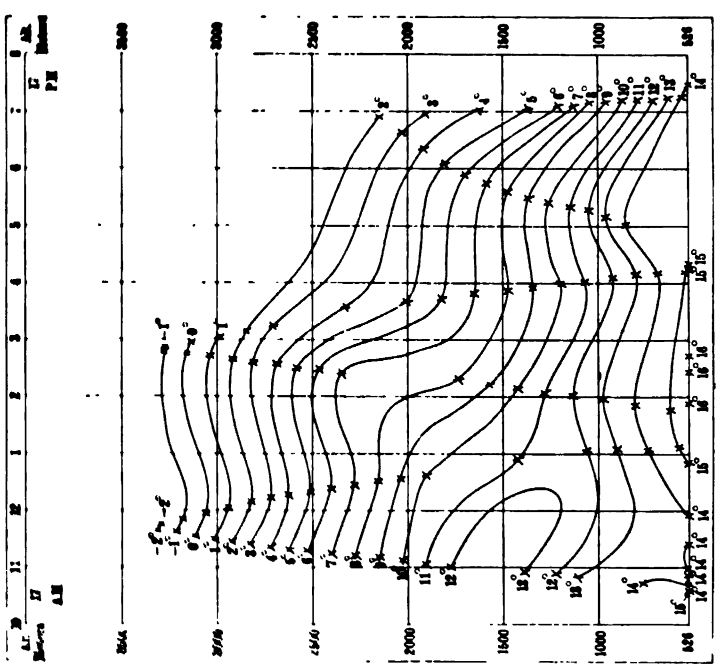

FIG. 56.—Free air isotherms above Mount Weather; observed January 17, 1913.

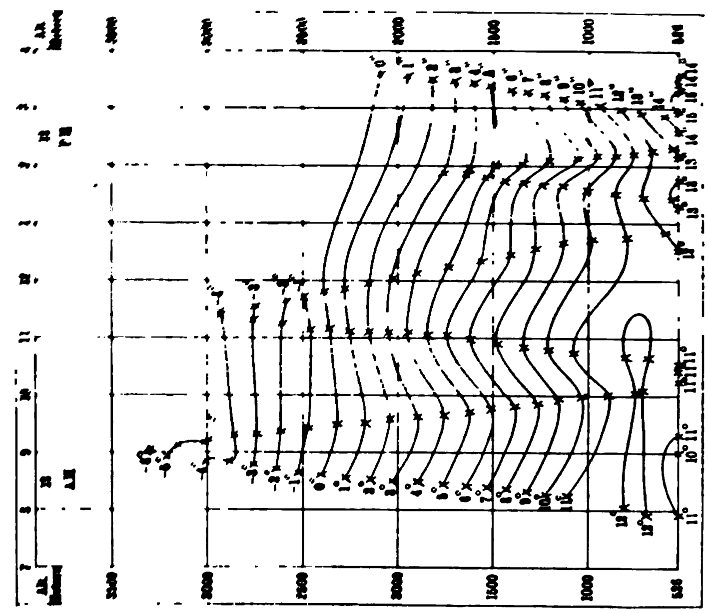

FIG. 57.—Free air isotherms above Mount Weather; observed January 18, 1913.

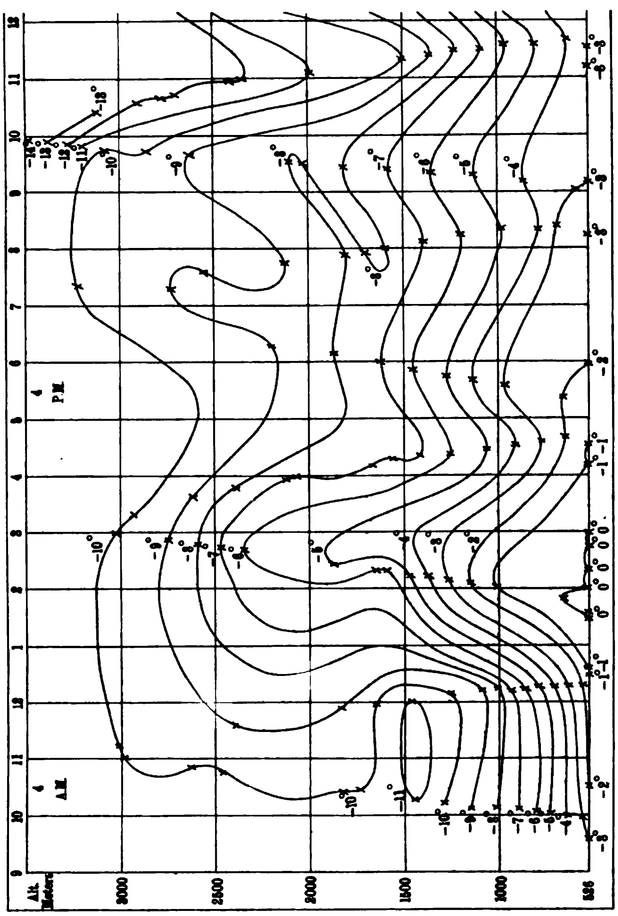

FIG. 58a.—Free air isotherms above Mount Weather; observed February 4, 5, 1913.

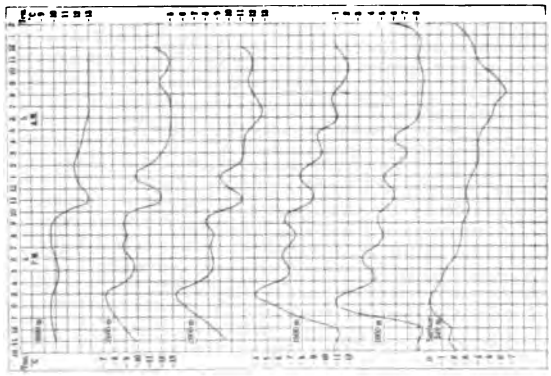

FIG. 59.—Temperatures above Mount Weather; observed February 4, 5, 1913.

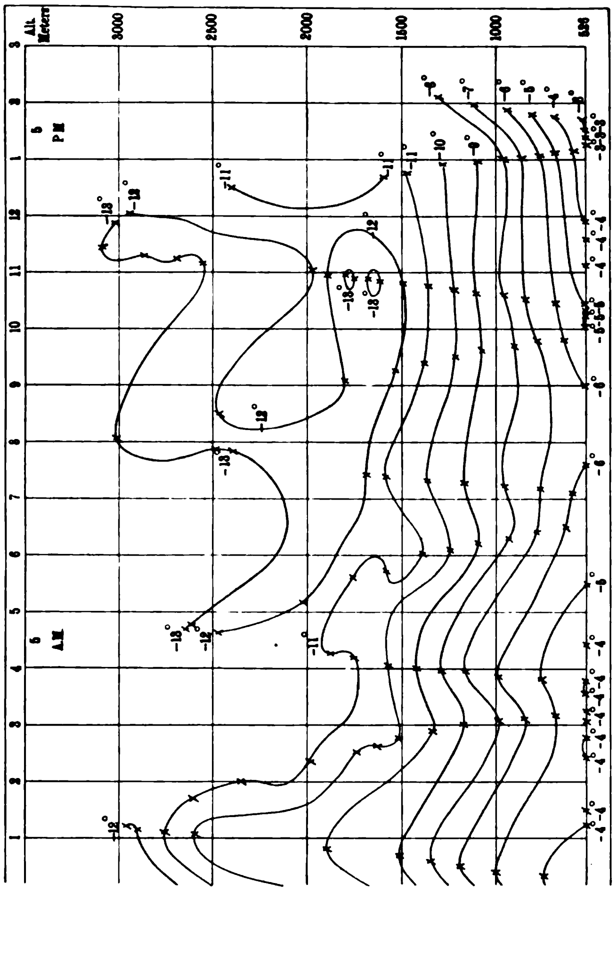

FIG. 58b.—Free air isotherms above Mount Weather; observed February 4, 5, 1913.

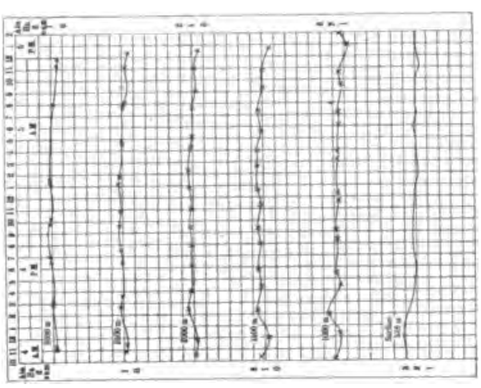

FIG. 60.—Absolute humidities above Mount Weather; observed February 4, 5, 1913.

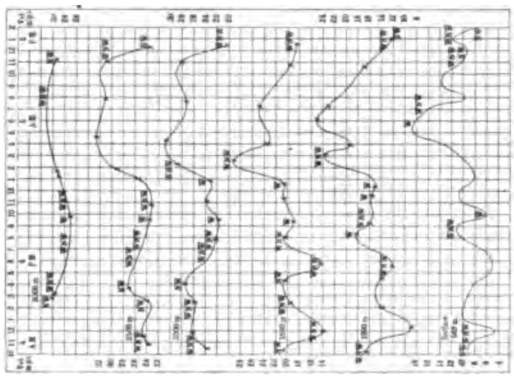

FIG. 61.—Wind velocities and directions above Mount Weather; observed February 4, 5, 1913.

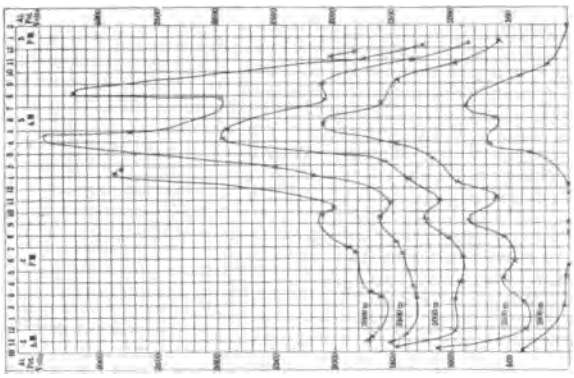

FIG. 62.—Atmospheric electric potentials above Mount Weather; observed February 4, 5, 1913.

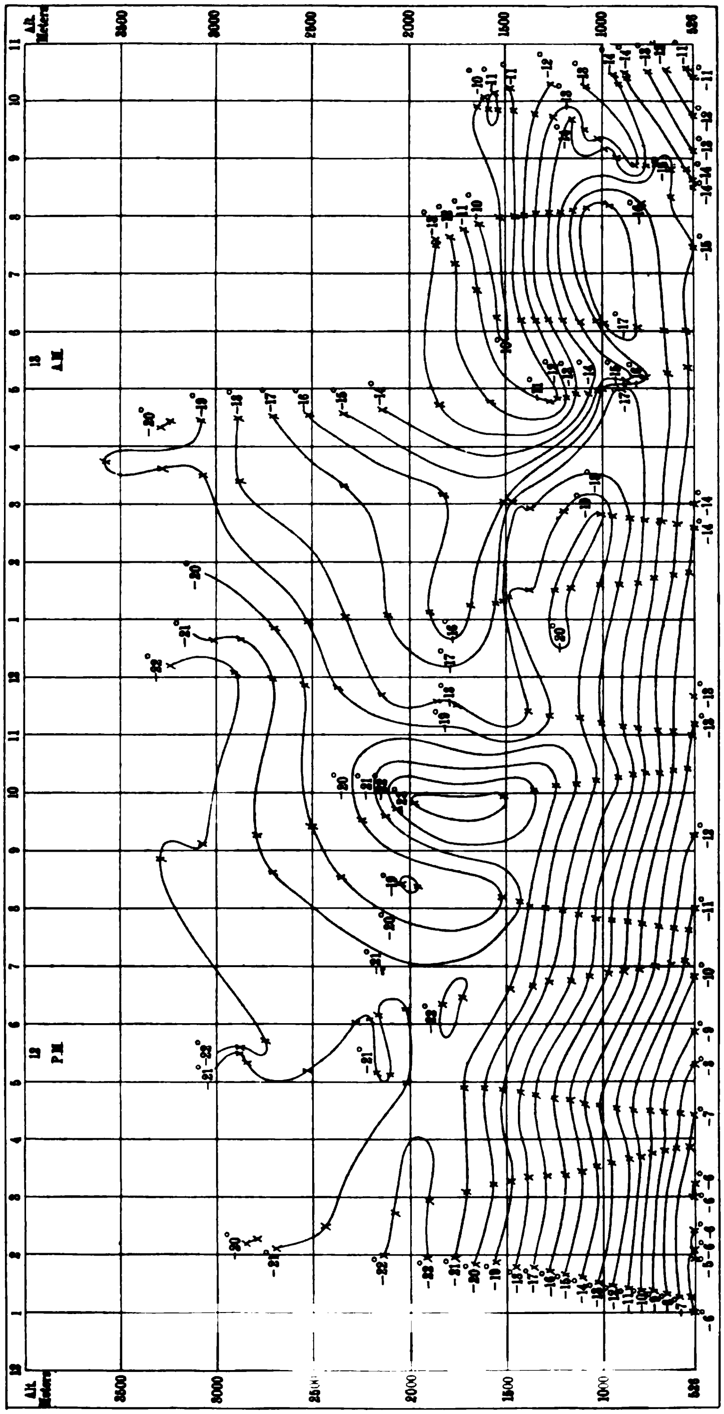

FIG. 63.—Free air isotherms above Mount Weather; observed February 12, 13, 1913.

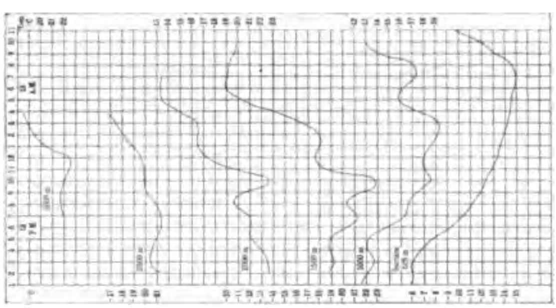

FIG. 64.—Temperatures above Mount Weather; observed February 12, 13, 1913.

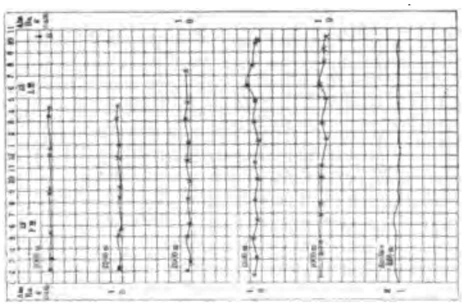

FIG. 65.—Absolute humidities above Mount Weather; observed February 12, 13, 1913.

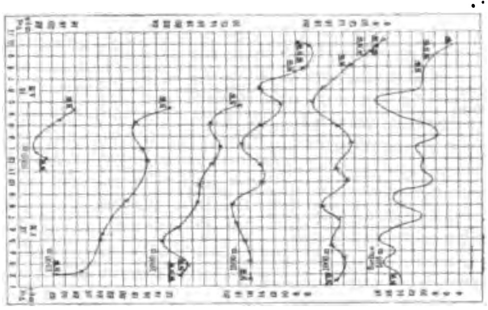

FIG. 66.—Wind velocities and directions above Mount Weather; observed February 12, 13, 1913.

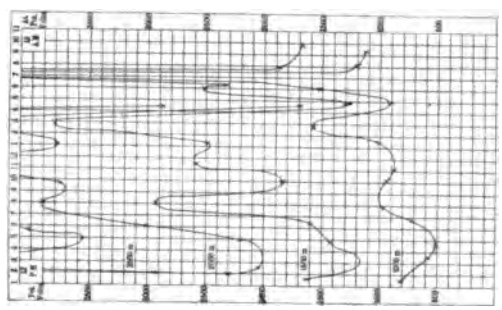

Fig. 67a.—Atmospheric electric potentials above Mount Weather; observed February 12, 13, 1913.

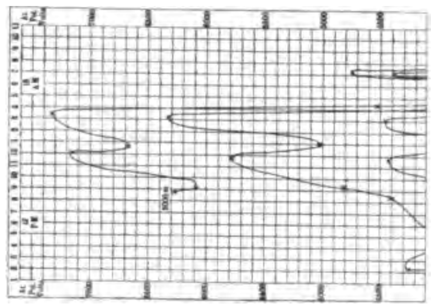

Fig. 67b.—Atmospheric electric potentials above Mount Weather; observed February 12, 13, 1913.

W. B. No. 524 Issued February 14, 1914

U. S. DEPARTMENT OF AGRICULTURE

WEATHER BUREAU

CHARLES F. MARVIN, Chief

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OF THE

MOUNT WEATHER OBSERVATORY

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1914

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5. THE ZODIACAL LIGHT.

By MAXWELL HALL.

[Dated Jamaica, West Indies, Oct. 21, 1913.]

In a former article on this subject, published in the United States Monthly Weather Review for March, 1906, I gave an account of the results obtained after some 30 years of observation; and it was there explained that failing to observe any changes in its position, breadth, and illumination which could not be accounted for by its varying inclination to the horizon and by varying atmospheric effects, some very careful measures were taken, in 1899 and 1901, which showed that the band of light did not absolutely coincide with the ecliptic, but that it rather followed the invariable plane of the solar system.

The writer of the article on the zodiacal light in the last edition of the Encyclopædia Britannica, in referring to this work, suggested that the observations should be continued throughout a year; and after I had retired from official duties I recommenced the observations and continued them from December, 1911, to November, 1912. Since that time much has happened to interfere with even the reduction of the observations, and as the former results have been confirmed and developed it seems better to publish the results obtained up to the present time rather than trust to the probability of making many more of these rather difficult observations.

The late Prof. Simon Newcomb wrote me asking whether the longitudes referred to in that article were geocentric or heliocentric. They certainly were the former; neither did it then appear possible to consider heliocentric longitudes except in the case of the *gegenschein*, or counterglow. This subject will be dealt with later on.

In figure 1 let the circle represent the orbit of the earth and the continuous line the line of nodes of the invariable plane, the ascending node being in heliocentric longitude 107° and the inclination of that plane to the ecliptic being 1° 35′.

Then, supposing that the plane of the zodiacal light coincides with the invariable plane, when the earth in January is at E_1 on the line of nodes, a point A on the western and morning branch of the zodiacal light 90° from the sun should be 1° 35′ above the ecliptic, but a point G 90° from the sun on the eastern and evening branch should be 1° 35′ below.

When the earth in April is at E_2 at right angles to the line of nodes, all that part of the zodiacal light near B in opposition to the sun should be more than 1° 35′ above the ecliptic.

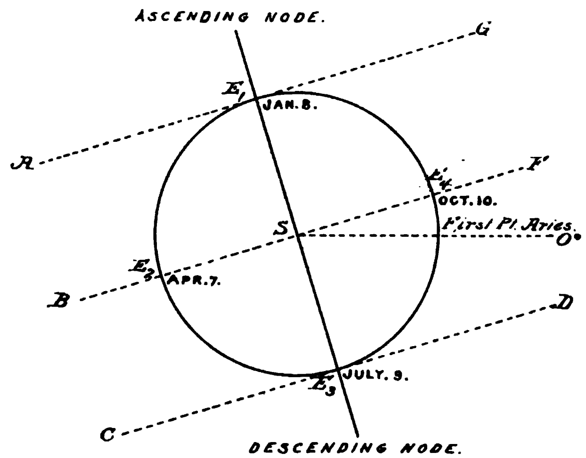

FIG. 1.—The orbit of the earth and the nodes of the invariable plane.

When the earth in July is at E_3 on the line of nodes again, a point C 90° from the sun on the eastern and evening branch should be 1° 35′ above the ecliptic, but a point D 90° from the sun on the western and morning branch should be 1° 35′ below.

When the earth in October is at E_4 at right angles to the line of nodes again, all that part near F in opposition to the sun should be more than 1° 35′ below the ecliptic.

When the earth is at E_1 and E_3 the parts of the zodiacal light opposite to the sun can not be seen on account of the milky way.

We thus have six tests to show how far the zodiacal light coincides with the invariable plane; and we shall, in Table I, pick out from the whole series all the observations which apply to these tests and arrange them according to the days of the month.

TABLE I.

Position of earth.	Date.	Distance of point from sun.		Geocentric latitude of point.	
		°		°	
E_1, January, W. branch 90° from sun..	1899, Jan. 12...	103	91	+3	+2
	1899, Jan. 12...	74		+1	
	1899, Jan. 17...	108		+3	
	1899, Jan. 17...	73		0	
	1899, Jan. 20...	111		+3	
	1912, Jan. 30...	78		+1	
E_1, January, E. branch 90° from sun..	1899, Jan 8.....	76	82	−3	−2
	1912, Jan. 8....	92		0	
	1899, Jan. 11...	77		−2	
	1912, Jan. 23...	84		−1.5	
E_2, April, opposition to the sun........	1912, Mar. 14...	173	176	+4	+3
	1912, Mar. 16...	172		+1.5	
	1912, Mar. 17...	173		+1	
	1912, Mar. 18...	171		+2	
	1912, Apr. 4....	179		+3	
	1912, Apr. 6....	179		+3	
	1912, Apr. 11...	179		+3	
	1912, Apr. 18...	176		+4	
	1912, May 5....	178		+4.5	
E_3, July, W. branch 90° from sun	1912, June 13...	82	87	−3	−2
	1912, June 17...	108		−3.5	
	1912, June 22...	88		−2	
	1901, July 22...	82		−1	
	1901, July 23...	80		0	
	1912, July 23...	83		−1	
E_3, July, E. branch 90° from sun......	1912, June 13...	105	88	+3	+2
	1912, July 5....	84		+3	
	1912, July 5....	87		+1.5	
	1912, July 6....	83		+3	
	1912, July 6....	86		+1.5	
	1912, July 13...	81		+1.5	
E_4, October, opposition to the sun.....	1901, Sept. 10..	167	174	−3	−3
	1912, Sept. 10..	170		−6	
	1912, Sept. 15..	174		−7.5	
	1912, Oct. 20...	180		−2	
	1912, Oct. 30...	169		−2	
	1912, Nov. 1...	168		−2	
	1912, Nov. 1...	177		−3	
	1912, Nov. 2...	177		−2	
	1912, Nov. 5...	180		−1.5	
	1912, Nov. 6...	179		−1.5	

In each of the six cases the observations have stood the test remarkably well. From the 22 observations made when the earth was on the line of nodes the resulting inclination of the plane of the zodiacal light to that of the ecliptic is 1° 53′, which differs from that of the invariable plane by only 18′; but obviously the position of the line of nodes can not be obtained with the same accuracy, and we must determine its position later on.

It is to be noticed that from the 19 observations made near B and F in opposition the mean maximum geocentric latitude is 2° 58′. This result will be required later on.

From figure 1 we might form other groups besides those given in Table I. Thus from about January 8 to February 7 the morning observations in the western branch should all give + latitudes; and so on. It will be found that such groups are fairly satisfactory and therefore need not detain us here.

We must now refer to the observations made of the breadth of the zodiacal light. Arranging the groups so that the average geocentric longitudes are multiples of 10°, as far as possible, so as to avoid possible selection, we get the table following.

TABLE II.

Distance from sun		Breadth.		Branch.	Distance from sun.		Breadth.		Branch.
°		°			°		°		
20		28		W	73		19		W
20	21	29	32	W	74		25		W
21		34		W	75		24		W
24		38		W	76		15		E
32		58		E	76		23		W
32		27		W	77		23		E
34		16		E	80		11		W
34		24		E	81	80	17	23	W
37		30		E	81		28		E
42	40	27	28	E	82		15		W
43		22		E	82		36		W
45		22		E	83		20		E
45		40		E	84		22		E
45		19		E	86		32		E
45		25		E	86		31		E
46		23		E	86		28		E
47		40		E	87		28		E
47		14		W	88		34		W
47		26		W	103		12		W
49		25		W	103		15		E
49	50	14	25	W	105		5		E
51		30		E	106	104	16	17	E
53		23		W	108		17		W
53		10		W	108		24		W
53		32		W	111		18		W
54		38		E	114		11		W
54		21		W	115		12		E
55		27		E	148		12		W
55		20		W	152		20		E
55		25		W	157		11		E
55		25		W	168		14		E
56		26		W	170	167	11	12	W
56		27		W	173		10		E
56		27		E	174		10		W
56		15		E	179		7		E
56		23		W	180		10		....
56		24		W					
57		30		W					
58		28		E					
58		34		W					
59	60	26	26	E					
59		20		W					
60		42		E					
61		20		W					
62		28		E					
63		38		E					
64		23		E					
65		27		E					
65		30		E					
65		20		E					
65		23		E					
66		14		E					
67		26		W					
69		31		W					
69		32		E					

Separating the two branches the groups become—

TABLE III.

Distance from sun.	E branch.		W branch.		E and W combined.	
	Breadth.	Number of observations.	Breadth.	Number of observations.	Breadth.	Number of observations.
°	°		°		°	
21	....	....	32	4	32	4
40	28	11	27	1	28	12
50	36	3	21	7	25	10
60	27	15	25	14	26	29
80	25	8	21	8	23	16
104	15	5	19	6	17	11
167	12	5	11	4	12	9

It thus appears that on the whole the E branch is somewhat broader than the W branch. This is probably due to the circumstance that when the E branch is seen at its best in the evenings about March the air here is clearer than when the W branch is seen at its best in the mornings about September. We shall therefore use the combined breadths as giving on an average the true breadths of the zodiacal light at the different angular distances from the sun.

It was found that when the earth is at right angles to the line of nodes the maximum geocentric latitude in opposition was 2° 58′, and if we had been looking at a planet, the plane of whose orbit

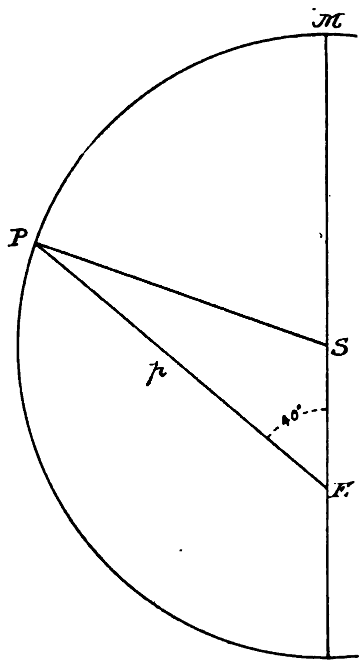

FIG. 2.—The distance and the apparent breadth of the zodiacal light.

coincided with that of the invariable plane, its distance from the earth could be easily computed: for if ρ were that distance taking the radius of the earth's orbit as unity we have $(1+\rho)$ tan 1° 35′$=\rho$ tan 2° 58′; whence $\rho=1.1$ and the radius of the orbit of the imaginary planet would be 2.1.

Now, if in figure 2 we lay off the angles SEP$=21°$, 40°, 50°, etc., taking the constant radius SP to be 2.1, we shall find that the lengths ρ bear a constant ratio to the corresponding observed breadths.

TABLE IV.

Angular distance from sun.	Breadth observed.	ρ	ρ divided by breadth.	Breadth computed.
°	°			°
21	32	3.0	0.094	32
40	28	2.8	.100	29
50	25	2.6	.104	27
60	26	2.4	.092	25
80	23	2.0	.087	21
104	17	1.6	.094	17
167	12	1.1	0.092	12
			[1]0.095	

[1] Mean.

The mean ratio is therefore 0.095; and if the breadths be computed as in the last column by means of ρ and this ratio they will be found to agree very well with the breadths observed.

On the other hand, from the observed breadth at any point on the zodiacal light we can obtain ρ, and then convert the geocentric longitude and latitude of the point into heliocentric longitude and latitude; we now proceed to reduce the observations.

As we have to form tables to assist these reductions it will be better, however, to consider the matter from a wider point of view; thus, we shall take the inclination of the plane of the zodiacal light to be 1° 35′, instead of 1° 53′, as likely to be more correct, and we shall compute ρ from the angular distance from the sun and thus reduce geocentric longitudes and latitudes, even in cases where the breadths were not observed.

As 1° 35′ was adopted in determining SP in figure 2 no change is therefore required; and

$$\sin \mathrm{SPE} = \frac{\mathrm{SE}}{\mathrm{SP}} \sin \mathrm{SEP},$$

where $\frac{\mathrm{SE}}{\mathrm{SP}} = 0.476$ approximately; so that $\angle \mathrm{MSP} = \angle \mathrm{SEP} + \angle \mathrm{SPE}$; and then helioc. long. = geoc. long $\pm \angle \mathrm{MSP}$, the upper sign applying to the eastern branch and the lower sign to the western.

Again, as $\rho = \mathrm{SP}\,\frac{\sin \mathrm{MSP}}{\sin \mathrm{SEP}}$, and as SP (helioc. lat.) $= \rho$ (geoc. lat.), we have helioc. lat. $= \frac{\rho}{\mathrm{SP}}$ (geoc. lat.).

Table V gives $\angle$MSP and ρ for each degree of the $\angle$SEP between 20° and 145° and then for every 5°; a small subsidiary table gives $\frac{\rho}{\mathrm{SP}}$.

It seems unnecessary to give all the details of the reduction; the heliocentric longitudes and latitudes were first arranged according to the dates of the observations; then the longitudes were arranged in numerical order, and groups were formed as in Table II; thus we obtain the following results (see Table V).

TABLE V.

∠ SEP.	∠ MSP.	ρ	∠ SEP.	∠ MSP.	ρ
°	°		°	°	
20	30	3.1	88	116	1.8
21	31	3.1	89	117	1.8
22	32	3.1	90	118	1.8
23	34	3.0	91	119	1.8
24	35	3.0	92	120	1.8
25	37	3.0	93	121	1.8
26	38	3.0	94	122	1.8
27	39	3.0	95	123	1.8
28	41	2.9	96	124	1.7
29	42	2.9	97	125	1.7
30	44	2.9	98	126	1.7
31	45	2.9	99	127	1.7
32	47	2.9	100	128	1.7
33	48	2.9	101	129	1.7
34	49	2.9	102	130	1.7
35	51	2.9	103	131	1.6
36	52	2.8	104	132	1.6
37	54	2.8	105	132	1.6
38	55	2.8	106	133	1.6
39	56	2.8	107	134	1.6
40	58	2.8	108	135	1.5
41	59	2.8	109	136	1.5
42	61	2.8	110	137	1.5
43	62	2.7	111	137	1.5
44	63	2.7	112	138	1.5
45	65	2.7	113	139	1.5
46	66	2.7	114	140	1.5
47	67	2.7	115	141	1.5
48	69	2.6	116	141	1.4
49	70	2.6	117	142	1.4
50	71	2.6	118	143	1.4
51	73	2.6	119	144	1.4
52	74	2.6	120	144	1.4
53	75	2.5	121	145	1.4
54	77	2.5	122	146	1.4
55	78	2.5	123	147	1.4
56	79	2.5	124	147	1.4
57	81	2.5	125	148	1.4
58	82	2.4	126	149	1.3
59	83	2.4	127	149	1.3
60	84	2.4	128	150	1.3
61	86	2.4	129	151	1.3
62	87	2.4	130	151	1.3
63	88	2.3	131	152	1.3
64	89	2.3	132	153	1.3
65	91	2.3	133	153	1.3
66	92	2.3	134	154	1.3
67	93	2.3	135	155	1.3
68	94	2.2	136	155	1.2
69	95	2.2	137	156	1.2
70	97	2.2	138	157	1.2
71	98	2.2	139	157	1.2
72	99	2.2	140	158	1.2
73	100	2.1	141	158	1.2
74	101	2.1	142	159	1.2
75	102	2.1	143	160	1.2
76	104	2.1	144	160	1.2
77	105	2.1	145	161	1.2
78	106	2.0	150	164	1.2
79	107	2.0	155	167	1.1
80	108	2.0	160	170	1.1
81	109	2.0	165	172	1.1
82	110	2.0	170	175	1.1
83	111	1.9	175	177	1.1
84	112	1.9	180	180	1.1
85	113	1.9	....	....	....
86	114	1.9	....	....	....
87	115	1.9	....	....	....

Subsidiary table for $\frac{\rho}{SP.}$

ρ	$\frac{\rho}{SP.}$	ρ	$\frac{\rho}{SP.}$
3.1	1.5	2.0	1.0
3.0	1.4	1.9	0.9
2.9	1.4	1.8	0.9
2.8	1.3	1.7	0.8
2.7	1.3	1.6	0.8
2.6	1.2	1.5	0.7
2.5	1.2	1.4	0.7
2.4	1.1	1.3	0.6
2.3	1.1	1.2	0.6
2.2	1.0	1.1	0.5
2.1	1.0		

TABLE VI.

Helio-centric longi-tude.	Helio-centric lati-tude.	Helio-centric longi-tude.	Helio-centric lati-tude.
°	°	°	°
10	−1.0	165	+1.8
30	−1.3	180	+2.4
40	−0.6	205	+1.5
60	−0.5	220	+2.3
82	−0.9	271	+0.8
99	−0.3	309	−0.4
130	+1.1	335	−1.2
155	+1.9	347	−1.4

If we draw a curve (fig. 3), taking the above heliocentric longitudes as abscissæ and the observed heliocentric latitudes as ordinates, we shall find the greatest latitude north to be $+2.1°$, the greatest latitude south to be $-1.4°$, the longitude of the ascending node to be 98°, and the longitude of the descending node to be 293°; whence, inclination of the plane of the ZL$=1° \ 45'$, longitude of ascending node$=105\frac{1}{2}°$; comparing these results with the 1° 35′ and 107° of the invariable plane, there can be no doubt as to their coincidence.

With regard to the angular breadth of the zodiacal light at different distances from the sun, a special series of observations was made in 1912 to discriminate between the breadth of its base along the horizon and the first streak of dawn or the last streak of evening twilight. If the axis of the zodiacal light is not nearly perpendicular to the horizon it seems impossible to do so, but when it is nearly perpendicular, and when the air is clear down to the very horizon, such observations can be made.

As a general result, when the zodiacal light is seen at its best and the air is as clear as possible, the breadth of the light at 21° distance from the sun is only 32°; but when there is much diffused light in the sky, which increases toward the horizon and forms there a white band of considerable width, the base of the zodiacal light

apparently becomes very broad, indeed, and mistakes have been previously made for want of this special investigation.

This general result was shown to be correct by the uniformity of the zenith distances of the sun when the times of appearance or disappearance of the streak of light of dawn or evening twilight were deduced. This zenith distance was 111° 27′, which is a good deal larger than that usually quoted, no attempt being made to separate the phenomena hitherto, as far as I am aware.

The drawing here given (fig. 4) of the elevation of the zodiacal light is on the same scale as the drawing given in the U. S. Monthly Weather Review, March, 1906. It will be found to differ from it in two respects; the breadth of the base has been reduced in consequence of eliminating the effect of diffused light along the horizon, and the breadth of the highest part has been increased.

A few observations have been made of the intensity of the zodiacal light at different distances from the sun as compared with the light of the sky at places at the same zenith distance as free from stars

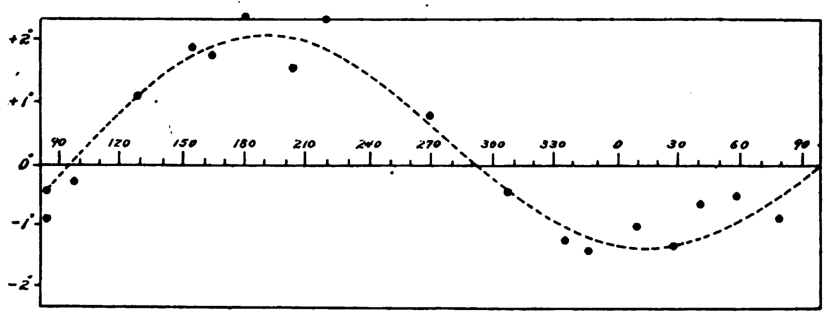

FIG. 3.—The observed heliocentric latitudes and longitudes of the center of the zodiacal light.

as possible; but the observations have not been reduced, as it is hoped to make some more. It may be remarked that these observations are very easy compared with those made to determine the boundaries of the zodiacal light.

In conclusion, my former spectroscopic work showing that the zodiacal light is reflected sunlight has been fully confirmed by Mr. Fath at Mount Wilson (Lick Observatory Bulletin, No. 165); a notice of this latter work is given in the Jamaica Monthly Weather Review for June, 1909. It confirms my former conclusion that the zodiacal light is the débris of cosmic dust which remained after the formation of the planets of the solar system.

The observations have been directed to the determination (1) of the geocentric longitudes and latitudes of points on the central axis of the zodiacal light, and (2) of its breadth at points whose geocentric longitudes at least are known.

In many cases the central axis is seen to pass over stars, or midway between two stars, or nearer to one star than the other, and so the geocentric longitude and latitude of the point can be found from a

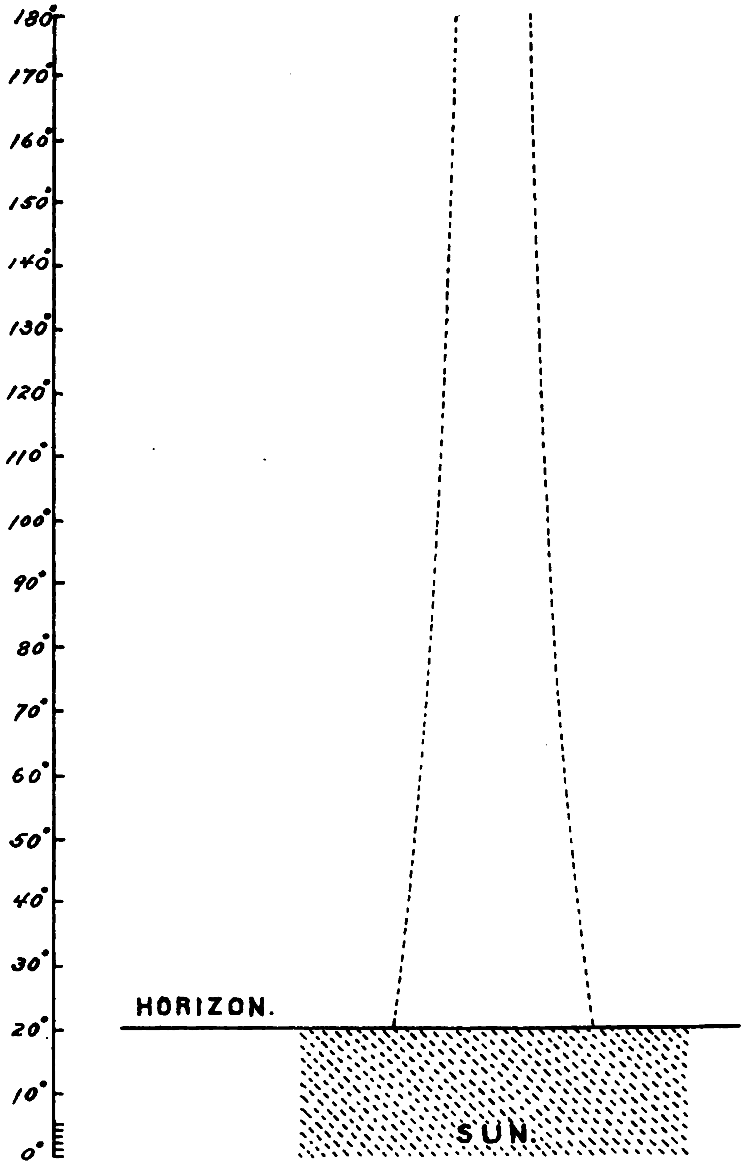

FIG. 4.—The resulting elevation of the zodiacal light, on the same scale as in the United States Monthly Weather Review, March, 1906.

star map. In other cases stars are seen on the boundary of the zodiacal light on each side of the ecliptic, and the line joining such stars need not be at right angles to the ecliptic; the middle point of

the line will give the geocentric longitude and latitude of a point on the central axis, but care must be taken to measure off the true breadth on the star map at right angles to the ecliptic.

On the E branch the distance of such a point from the sun is the geocentric longitude of point minus the geocentric longitude of sun; on the W branch it is the geocentric longitude of sun minus the geocentric longitude of point.

In the eighth column notes are given of the apparent quality of the night, and starlight is recorded as brilliant or bright or dim.

In the ninth column K. denotes Kémpshot, nearly 1,800 feet above sea level; B. H. denotes Brandon Hill, a house near Montego Bay; and P. denotes Parkhurst, a house 4 miles to the north of Kingston, the two latter places having small elevations of 200 or 300 feet, but with good views of the sky.

The time given is local mean time; this is only of consequence on 1912, September 11 and 23, and October 19 and 20, when sketches were made of the hills on the horizon and the two places were marked where the boundaries of the vertical zodiacal light cut them, then a sextant was used in daylight to find the angular distance between them, and hence the breadth of the zodiacal light, so many degrees above the horizon at the time noted.

It is hoped that the notes are sufficiently full so that the observations can be repeated, as it were, and the measures checked off on any star map. They were made at different times. The "Gegenschein" is the same as the "counterglow;" the "center" is the same as "central." Among the earliest observations of the series actual measurements were sometimes made of the breadth by means of a rough instrument devised for the purpose, but stars were subsequently preferred, although many of them were faint and further care was required.

TABLE VII. *Observations of the zodiacal light at Jamaica, West Indies, 1899–1912.*

Day (civil).	Hour.	Branch.	Geocentric longitude.	Geocentric latitude.	Breadth.	Distance from sun.	Starlight.	Place of observation.	Notes.	Sun's longitude.
			°	°	°	°				°
1899. Jan. 8	7 p. m....	E.	323	0	16	34	Bright....	K.	From β Aquarii to beyond δ Capricorni by half the distance between β Aquarii and δ Capricorni.	289
	7 p. m....	E.	5	−3	15	76	...do......	K.	Between γ Pegasi and β Ceti and nearer γ. Width less than half the distance	289
	7 p. m....	E.	34	(?)	5	105	...do......	K.	South of α and β Arietis. Faint. About 5° wide. Position of center not observed. Zodiacal light fainter than usual. Stopped by the Milky Way.	289
Jan. 9	7 p. m....	E.	335	0	22	45	...do......	B. H.	From α Aquarii to 2° beyond δ Aquarii	290
	7 p. m....	E.	324	−3	24	34	...do......	B. H.	From β Aquarii to two-thirds the distance between δ Capricorni and Fomalhaut; brightest at δ Capricorni; faint below Aries; as the Zodiacal light set it seemed to widen.	290
Jan. 10	8 p. m....	E.	356	−1	27	65	Dim......	B. H.	Breadth measured; half an hour later it was 30°, and then the sky clouded..........	291
Jan. 11	5 a. m....	W.	242	+1	25	49	Bright....	B. H.	Center at β Scorpii. Breadth measured. Much diffused light. Venus troublesome. Zodiacal light traced to Mars.	291
	8 p. m....	E.	9	−2	23	77	Dim......	B. H.	Center between γ Pegasi and η Ceti. Zodiacal light dim..........	292
Jan. 12	4 a. m.....	W.	189	+3	12	103	Bright....	B. H.	Center at γ Virginis. Diffused light..........	292
	4 a. m.....	W.	218	+1	25	74	...do......	B. H.	Center at Jupiter. Zodiacal light visible as far as Mars. Venus rising..........	292
Jan. 15	4.30 a. m..	W.	242	+2	23	53	...do......	K.	Center 1° north of β Scorpii. Zodiacal light faint from γ Virginis to Regulus.........	295
Jan. 17	2 a. m.....	W.	189	+3	17	108	Brilliant..	K.	Center at γ Virginis..........	297
	2 a. m.....	W.	149	+1	12	148	...do......	K.	Center at Regulus..........	297
	3 a. m.....	W.	224	0	19	73	...do......	K.	Center at α Libræ..........	297
	3 a. m.....	W.	242	+2	20	55	...do......	K.	Center 1° north of β Scorpii..........	297
Jan. 20	3 a. m.....	W.	189	+3	18	111	Bright....	B. H.	Center at γ Virginis..........	300
Jan. 21	5 a. m.....	W.	246	+6	25	55	Brilliant..	K.	Center between β Scorpii and ζ Ophiuchi. Zodiacal light faint. Venus kept out of sight.	301
Jan. 22	4 a. m.....	W.	246	+6	27	56	...do......	K.	Zodiacal light faint. Center as in last observation. Gegenschein in Cancer; it appears as a strengthening of the band for about 10° in length. G=125°. Up to the present it has been impossible to see the gegenschein on account of the Milky Way and Mars. Venus kept out of sight.	302
Jan. 31	7 to 8 p. m.	E.	10	−2	26	59	...do......	K.	Zodiacal light very bright. Center between γ Pegasi and η Ceti. Breadth from 1° sf. γ to 3° np. η. Gegenschein large and diffused.	311
Feb. 1	7 to 8 p. m.	E.	10	−2	28	58	Bright....	B. H.	Zodiacal light very bright. Very much broader at horizon than at Kempshot. Breadth from γ Pegasi to 2° np. η Ceti. Center at half breadth.	312
Feb. 5	7 p. m....	E.	349	(?)	58	32	...do......	K.	Zodiacal light very bright. At 7:5 p. m. breadth 12° above horizon=60°; at 7:20 breadth 15° above horizon=56°.	317
Feb. 6	2.30 a. m...	W.	....	....	....	....	Brilliant..	K.	Much diffused light. Zodiacal light faint. Branch traced to the gegenschein, which is very plain between Regulus and Præsepe. G=135°; latitude 0°.	317
	2.30 a. m..	W.	242	+5	24	75	...do......	K.	Breadth from π Scorpii to δ and ε Ophiuchi. Moon rose at 2:55..........	317
Mar. 4	7 to 8 p. m.	E.	40	−2	27	56	Dim......	K.	Zodiacal light very bright. Breadth from α Arietis to α Ceti, but greatest illumination nearer α Arietis instead of midway. Gegenschein very plain between Regulus and β Virginis, 30° in length. G=160°; latitude 0°. (Absent from station between Feb. 6 and Mar. 4.)	344

Mar. 5	7:20 to 9 p.m.	E.	40	−2	27	55	Bright	K.	Zodiacal light very bright. At 7:20 breadth from α Arietis toward α Ceti was only 20°: at 9 p. m. about 10° above horizon it was 27°. This broadening was noticed last night also. The brightest part of the zodiacal light is on the ecliptic and not at −2°. At 7:20 the zodiacal light combined with twilight at the horizon, so that it was 70° broad along the horizon. Gegenschein as last night.	345
Mar. 20	4:30 to 5 a.m.	W.					...do	K.	Zodiacal light very feeble. Venus interferes below the Milky Way. Above Milky Way zodiacal light not seen till near the Gegenschein on the ecliptic near β Leonis. G=170°. The zodiacal light was to the north of Venus. No measures possible.	0
1901. July 21	4 a. m.	W.	63	−1	25	55	Dim	K.	Center between η and α Tauri	118
	4 a. m.	W.	4	−1	11	114	...do	K.	Center on line from α Andromedæ through γ Pegasi at equal distance beyond γ Pegasi. Zodiacal light barely seen 20° beyond this point, the sky getting very dim. Zodiacal light faint on the whole.	118
July 22	3 a. m.	W.	37	−1	15	82	...do	K.	Center between α Arietis and γ Ceti	119
	3 a. m.	W.	4	+2		115	...do	K.	Center on line from α Andromedæ through γ Pegasi and three-fourths the distance beyond the latter. Zodiacal light can not be seen beyond; dim sky.	119
July 23	4 a. m.	W.						K.	Zodiacal light very bright near horizon; very dim near Aries, where the sky also becomes dim.	120
	4 a. m.	W.	88	−1	27	32	Bright	K.	Center between α Orionis and θ Aurigæ	120
	4 a. m.	W.	83	+1		37	...do	K.	Center between β and ζ Tauri and nearer the latter	120
	4 a. m.	W.	63	−1		57	Dim	K.	Center between η and α Tauri	120
	4 a. m.	W.	40	0	11	80	...do	K.	Center between α Arietis and α Ceti, and nearer the former	120
Sept. 10	4 a. m.	W.	111	−2	26	56	Bright	K.	Center between Procyon and Castor. Small moon 10° above eastern horizon	167
	4 a. m.	W.	0	−3	(26)	167	...do	K.	The Gegenschein appeared very broad between β Ceti and a point between α and γ Pegasi; breadth 2[illegible]°; tapering up from the western horizon. The band across the sky was hardly seen; perhaps the moon interfered. The Gegenschein was very uniform; no central condensation. G=0°; lat. −3°.	167
Oct. 1	8 p. m.	E.	212	(+17)		21	...do	K.	Zodiacal light greatly diffused along the western horizon. The light extends between Arcturus and Venus up to the stars in the head of Scorpio. The band was not seen but the Gegenschein was pretty plain. The very small inclination of the zodiacal light to the horizon is due to the diffused light along the horizon.	188
Oct. 5	8 p. m.	E.					...do	K.	Zodiacal light very clear. Band visible. Gegenschein very plain. It appears as a feeble zodiacal light tapering above the eastern horizon; same form; dull, uniform light; 20° above the horizon it was 20° in width, and tapered up about 40° above the horizon to long. 0°. G=20°.	192
1911. Dec. 13	7 p. m.	E.	313	−0.5		52	...do	K.	Zodiacal light bright. Central line passes over θ Capricorni and has been so seen for some nights past.	26
Dec. 15	8 p. m.	E.	340	−0.5		77	...do	K.	Central line over λ Aquarii	263
	8 p. m.	E.	313	−0.5		50	...do	K.	Central line over θ Capricorni	263
Dec. 16	8 p. m.	E.	340	−0.5		76	...do	K.	Central line over λ Aquarii	264
	8 p. m.	E.	313	−0.5		49	...do	K.	Central line over θ Capricorni. ZL pretty bright	264
Dec. 17	8 p. m.	E.	313	−0.5		48	...do	K.	Central over θ Capricorni	265
	8 p. m.	E.	340	−0.5		75	...do	K.	Central over λ Aquarii	265
	8 p. m.	E.	19	−1		114	...do	K.	Central between ϵ and μ Piscium	265
1912. Jan. 8	8 p. m.	E.	340	−0.5		53	...do	K.	Central over λ Aquarii	287
	8 p. m.	E.	19	0		92	...do	K.	Central over ζ Piscium. Counterglow strong in E.	287
Jan. 22	8 p. m.	E.	0	−1.5		58	...do	K.	Central between ω Piscium and ι Ceti	302
Jan. 23	8 p. m.	E.	27	−1.5		84	...do	K.	Central over o Piscium	303
Jan. 29	5 a. m.	W.	189	+2.5		119	...do	K.	Central over γ Virginis	308

TABLE VII.—*Observation of zodiacal light*—Continued.

Day (civil).	Hour.	Branch.	Geocentric longitude.	Geocentric latitude.	Breadth.	Distance from sun.	Starlight.	Place of observation.	Notes.	Sun's longitude.
			°	°	°	°				°
1912.										
Jan. 30	5 a. m.	W.	189	+2.5	....	120	Bright	K.	Central over γ Virginis	309
	5 a. m.	W.	231	+1	....	78	..do..	K.	Central between γ and ι Libræ	309
Feb. 12	8 p. m.	E.	26	+2.5	....	63	..do..	K.	Central 1° north of π Piscium	323
Feb. 17	4 a. m.	W.	180	+1	....	147	..do..	K.	Central near β and η Virginis	327
Feb. 19	8 p. m.	E.	26	+1.5	15	56	..do..	K.	Central over π Piscium. Breadth=13° from η Arietis to α Piscium; at 9 p. m.=17°, a little beyond these stars. ZL very bright; much diffused light.	330
Mar. 12	8 p. m.	E.	37	−1	19	45	..do..	P.	ZL bright. Breadth from 2° S. of α Arietis to 2° N. of γ Ceti.	352
	8 p. m.	E.	67	+1	....	75	..do..	P.	Central over ε Tauri.	352
	8 p. m.	E.	149	+1	....	157	..do..	P.	Center of Gegenschein at Regulus; it reached to ε and ι Leonis	352
Mar. 13	8 p. m.	E.	39	−1.5	23	46	..do..	P.	Breadth taken between α Arietis and α Ceti. ZL bright; clouds passing.	353
	8 p. m.	E.	59	−1	14	66	..do..	P.	Breadth taken between N. side of Pleiades and λ Tauri.	353
Mar. 14	8 p. m.	E.	37	−1	22	43	Brilliant	P.	Breadth taken between α Arietis and γ Ceti. Very bright.	354
	8 p. m.	E.	46	0	....	52	..do..	P.	Central 1½° N. of Saturn.	354
	8 p. m.	E.	167	+4	10	173	..do..	P.	Gegenschein very strong, 30° in length; breadth twice the distance between ε and ι Leonis.	354
Mar. 15	8 p. m.	E.	60	−1	20	65	..do..	P.	Very bright. Breadth from between Pleiades and ζ Persei to between λ and ν Tauri. From the Hyades to Præsepe the ZL can not be seen on account of the Milky Way.	355
	8 p. m.	E.	149	+1	....	154	..do..	P.	Gegenschein very strong from Præsepe through Regulus to below ε and ι Leonis	355
Mar. 16	8 p. m.	E.	61	+1	23	65	..do..	P.	Breadth from ζ Persei to between λ and ν Tauri. Bright.	356
	8 p. m.	E.	149	+1	....	153	..do..	P.	Gegenschein dim between Regulus and ε Leonis	356
	8 p. m.	E.	168	+1.5	....	172	..do..	P.		356
Mar. 17	4 to 5 a. m.	W.	184	+1	....	173	Dim	P.	Very strong diffused light. ZL hardly visible between η Virginis and α Libræ, it passes over these stars and N. of Spica.	357
	4 to 5 a. m.	W.	214	+0.5	....	143	..do..	P.		357
Mar. 17	4 to 5 a.m.	W.	304	+1	10	53	..do..	P.	Central over π Capricorni where it is about 10° broad.	357
	4 to 5 a.m.	W.	322	+1	....	35	..do..	P.	Central one-third the distance between δ Capricorni and β Aquarii	357
	8 p.m.	E.	61	+1	23	64	Bright	P.	As on the 16th	357
	8 p.m.	E.	149	+1	....	152	..do..	P.	..do..	357
Mar. 18	5 a.m.	W.	304	+1	....	54	..do..	P.	Central over π Capricorni.	358
	5 a.m.	W.	311	+1	14	47	..do..	P.	Breadth from μ Aquarii to 2° S. of ψ Capricorni.	358
	5 a.m.	W.	187	+2	....	171	..do..	P.	ZL hardly visible in Virgo: strongest about γ and η.	358
Mar. 20	5 a.m.	W.	284	+1.5	....	76	..do..	P.	Over π and ο Sagittarii: very dim.	0
	5 a.m.	W.	304	+1	....	56	..do..	P.	Over π Capricorni	0
	5 a.m.	W.	311	+1	14	49	..do..	P.	Breadth from μ Aquarii to 2° S. of ψ Capricorni. ZL inclined at angle of 45° to horizon, and measures difficult.	0
Apr. 4	8 p.m.	E.	60	−1	25	45	..do..	K.	Between ζ and ο Persei and μ and ν Tauri.	15
	8 p.m.	E.	67	−3	....	32	..do..	K.	Central over ε Tauri	15
	8 p.m.	E.	140	+5	....	131	..do..	K.	Central over η Leonis	15
	8 p.m.	W.	196	+3	....	179	..do..	K.	Counterglow between δ and α Virginis	16
Apr. 6	8 p.m.	E.	59	0	27	42	Brilliant	K.	From 2° north of ο Persei to between μ and ν Tauri. Great central condensation along the axis. ZL bright.	17

Apr. 6	8 p.m.	E.	196	+3		179	...do.	K.	Counterglow as on the 4th	17
Apr. 7	8 p.m.	E.	55	+1		37	...do.	K.	Great display of the ZL: great breadth. The center was between Saturn and the Pleiades.	18
	8 p.m.	E.	72	+1.5	38	54	...do.	K.	Breadth from ϵ Persei to γ Orionis, estimated by tracing the boundary of the ZL upward to the milky way.	18
	8 p.m.	E.	170	+1	20	152	...do.	K.	Central line from Regulus to γ Virginis: half breadth 10° estimated from β Leonis to this line. Counterglow as on the 4th and 6th. This display may have been due to unusual transparency of the air. The milky way was half as broad again south of Procyon as given in the maps.	18
Apr. 11	8 p.m.	E.					Bright	K.	Milky way interferes near Taurus and Gemini	22
	8 p.m.	E.	137	+1		115	...do.	K.	Central between Præsepe and Regulus	22
	8 p.m.	W.	203	+3		179	...do.	K.	Counterglow between Spica and ζ Virginis	22
Apr. 12	8 p.m.	E.	63	−1		40	Dim	K.	ZL very bright at central line, but there is much diffused light in the sky. Center between Pleiades and Aldebaran.	23
	8 p.m.	E.	70		40	47	...do.	K.	Half breadth on south side from π^5 and π^6 Orionis to central line 20°; milky way interferes on the north side.	23
	8 p.m.	E.	126	+1	15	103	...do.	K.	Central between Præsepe and Regulus: at Præsepe 15° broad. Counterglow hardly seen on account of diffused light.	23
Apr. 14	8 p.m.	E.	130	+2.5	16	106	Brilliant	K.	Breadth between ϵ and κ Cancri. ZL very bright.	25
Apr. 16	4:45 a.m.						Dim	K.	Diffused light so great as to render the fainter stars, the milky way, and the ZL invisible.	25
Apr. 18	9 p.m.	E.	115	+1.5	32	86	Brilliant	K.	From a point two-thirds the distance from Castor to 31 Lyncis to β Canis Minoris. ZL strong.	29
	9 p.m.	W.	213	+4		176	...do.	K.	Counterglow strong: center about ι, κ, and λ Virginis.	29
Apr. 25	4 a.m.	W.	334	+1	20	61	...do.	K.	Central between α and δ Aquarii: not much diffused light	35
	4 a.m.	W.	304	+1		91	...do.	K.	Central over π and ρ Capricorni. Hardly seen in Libra on account of Jupiter in Scorpio.	35
May 5	8 p.m.	E.	82	+2	36	37	Bright	K.	Central between β and ζ Tauri: extends on the left to γ Orionis: milky way interferes on the right.	45
	8 p.m.	E.	131	+3	31	86	...do.	K.	Central between η and ϵ Hydræ and α Leonis Minoris	45
	8 p.m.	E.	202	+3	11	157	...do.	K.	Central between α and ζ Virginis	45
	8 p.m.	W.	227	+4.5		178	...do.	K.	Counterglow between α and β Libræ	45
May 20	4 a.m.	W.	3	+1.5	24	56	...do.	P.	Central between γ Pegasi and ϵ Ceti. Diffused light low down	59
	4 a.m.	W.	338	0	17	81	...do.	P.	Central between η and ζ Aquarii and δ Aquarii. MW bright in zenith	59
June 7	8 p.m.	E.					...do.	K	Heavy May rains leaving cirro-stratus at night have prevented any observation since the full moon in May.	77
	8 p.m.	E.	146	+5	32	69	...do.	K.	Breadth from 15 Sextantis to 21 Leonis Minoris.	77
	8 p.m.	E.	124	+2		47	...do.	K.	Central over Mars.	77
	8 p.m.	E.	189	+3		112	...do.	K.	Central over γ Virginis	77
June 11	9 p.m.	E.	129	+2		48	...do.	K.	Central over Mars	81
	9 p.m.	E.	144	+3	38	63	...do.	K.	Breadth from one-fourth distance from Regulus to λ and μ Ursæ Majoris to three-fourths distance from Regulus to α Hydræ.	81
	9 p.m.	E.	147	+3		66	...do.	K.	Central between Regulus and η Leonis	81
	9 p.m.	E.	196	+1	12	115	...do.	K.	Central between Spica and γ Virginis: breadth twice from γ to δ Virginis	81
June 13	3 a.m.	W.	321	−3		121	Brilliant	K.	Central over γ and δ Capricorni	82
	3 a.m.	W.	0	−3	36	82	...do.	K.	From between α and γ Pegasi to β Ceti	82
	8 p.m.	E.	143	+4	42	60	...do.	K.	From south of λ and μ Ursæ Majoris to 5° north of α Hydræ	83
	8 p.m.	E.	147	+5		64	...do.	K.	Central over η Leonis — Much diffused light above NW. horizon so that the ZL appears to broaden northward.	83
	8 p.m.	E.	188	+3		105	...do.	K.	Central over γ Virginis	83
	8 p.m.	E.	223	0		140	...do.	K.	Central over α Libræ	83
June 15	4 a.m.	W.	15	−2.5	31	69	...do.	K.	Northern boundary stretches from between α Arietis and α Triang. to γ Pegasi: southern boundary from β Ceti to η and θ Ceti. ZL very bright: so also milky way.	84

TABLE VII.—*Observation of zodiacal light*—Continued.

Day (civil).	Hour.	Branch.	Geocentric longitude.	Geocentric latitude.	Breadth.	Distance from sun.	Starlight.	Place of observation.	Notes.	Sun's longitude.
1912.			°	°	°	°				°
June 17	4 a.m.	W.	338	−3.5	24	108	Bright	K.	From η and γ Aquarii to 88 and 98 Aquarii	86
June 22	4 a.m.	W.	4	−2	34	88	...do	K.	From 1° north of γ Pegasi to 1° north of β Ceti	92
	4 a.m.	W.	39	+1	32	53	...do	K.	From α Trianguli to α Ceti. Much diffused light	92
	4 a.m.	W.	58	+1.5		34	...do	K.	Central between the Pleiades and Saturn	92
July 5	8 p.m.	E.	189	+3		84	Brilliant	K.	Central over γ Virginis	105
	8 p.m.	E.	192	+1.5	28	87	...do	K.	From ϵ Virginis to δ Corvi	105
July 6	9 p.m.	E.	189	+3		83	...do	K.	Confirming last night's observation	106
	9 p.m.	E.	192	+1.5	28	86	...do	K.	...do	106
July 11	8 to 9 p.m.	E.					Bright	K.	Much diffused light. ZL and MW both indistinct. No measures possible	
July 13	8 to 9 p.m.	E.	192	+1.5	28	81	...do	K.	From ϵ Virginis to δ Corvi, as on the 5th and 6th	111
July 23	4 a.m.	W.	37	−1	20	83	...do	P.	From the lucidæ of Aries to those in the head of Cetus	120
	4 a.m.	W.	60	+1		60	...do	P.	Central between the Pleiades and Saturn	120
	4 a.m.	W.	82	0		38	...do	P.	Central between β and ζ Tauri	120
Aug. 2	8 p.m.	E.	192	+1.5	28	62	...do	P.	From ϵ Virginis to δ Corvi. ZL badly situated for observation	130
Aug. 31	8 p.m.	E.	200	0		42	Dim	K.	Central between α and θ Virginis	158
	8 p.m.	E.	224	0		66	...do	K.	Central over or near α Libræ. ZL poor compared with MW	158
Sept. 2	8 p.m.	E.	200	0		40	...do	K.	Central between α and θ Virginis	160
	8 p.m.	E.	225	0	30	65	...do	K.	From between β Libræ and μ Serpentis to π Hydræ. ZL very badly situated for observation; seeing poor, especially near horizon. Clouds passing, and at times constant sheet lightning.	160
Sept. 10	4 a.m.	W.	357	−6	11	170	Bright	K.	Central over 30 and 33 Piscium. Breadth, one-third distance γ Pegasi to β Ceti	167
	4 a.m.	W.	27	−9		140	...do	K.	Central over α Piscium	167
	4 a.m.	W.	113	−3	21	54	...do	K.	Central between Castor and Procyon. Breadth, Pollux to 2° north of Procyon	167
	4 a.m.	W.	126	0		41	...do	K.	Central 1° or 2° south of Præsepe. Seeing very good	167
Sept. 11	4 a.m.	W.	38	−3		130	...do	K.	Central between α Arietis and α Ceti	168
	4 a.m.	W.	113	0		55	...do	K.	Central between Castor and point 5° north of Procyon	168
	4:41 a.m.	W.	(147)		28	20	...do	K.	Breadth 3° above horizon taken subsequently by sextant by means of marks on the hills. Seeing very good. No diffused light along horizon.	168
Sept. 15	4 a.m.	W.	358	−7.5	10	174	...do	K.	Counterglow strong, 20° along ecliptic. Central with regard to latitude between ι Ceti and 30 Piscium. Breadth estimated.	172
	4 a.m.	W.	113	−3	20	59	...do	K.	Central between Castor and Procyon. Breadth from Pollux to 3° north of Procyon.	172
Sept. 21	4:30 a.m.	W.	149	+1		29	...do	K.	Central over Regulus	178
Sept. 23	4 a.m.	W.	113	−2.5	26	67	Brilliant	K.	From 2° north of Procyon to Castor	180
	4 a.m.	W.	133	+1	26	47	...do	K.	From point between ϵ Leonis and α Lyncis to δ and ϵ Hydræ	180
	4:34 a.m.	W.	(156)		38	24	...do	K.	Breadth 5° above horizon taken subsequently by sextant by means of marks on the hills.	180
Oct. 18	4 a.m.	W.	149	+1	23	56	Dim	K.	Central over Regulus. From ζ Leonis to halfway between Regulus and α Hydræ	205
Oct. 19	4 a.m.	W.	149	+1	30	57	Bright	K.	From 3° north of ζ Leonis to two-thirds distance between Regulus and α Hydræ. Counterglow hardly visible. Much diffused light.	206
	4:39 a.m.	W.	186	+2	29	20	...do	K.	Position of base noted on the hills on the horizon and subsequent sextant readings. Good observations.	206

Oct. 20	4 to 5 a.m.	W.	149	+1	34	58	...do......	K.	Central over Regulus; from 3° north of α Hydræ to 3° north of ζ Leonis. ZL uniform width up to Regulus, and then suddenly decreases.	207
	4 to 5 a.m.	W.	27	−2	10	180	...do......	K.	Counterglow central over ο Piscium; about 10° broad, 30° in length. Sky darker than last night.	207
	4:36 a.m..	W.	186	+2	34	21	...do......	K.	Position of base noted, and subsequent measurements taken........................	207
Oct. 29	7:30 p.m..	E.	322	−1	....	106	...do......	K.	Central 1° north of γ and δ Capricorni..	216
	7:30 p.m..	E.	17	+1	....	161	...do......	K.	Central over ε Piscium..	216
Oct. 30	7:30 p.m..	E.	285	+1	....	68	...do......	K.	Central over π Sagittarii where the ZL joins the MW........................	217
	7:30 p.m..	E.	313	+1	....	96	...do......	K.	Central between β and γ Capricorni and nearer the latter........................	217
	7.30 p.m..	E.	26	−2	....	169	...do......	K.	Central over ο Piscium..	217
Oct. 31	7:30 p.m..	E.	292	−2	....	74	...do......	K.	Central position estimated; much diffused light........................	218
Nov. 1	7:30 p.m..	E.	303	−4.5	22	84	...do......	K.	From α Capricorni to α Microscopii..	219
	7:30 p.m..	E.	305	−3	....	86	...do......	K.	Central between π, ρ, σ Capricorni and ψ Capricorni. Band visible whole way to counterglow in Pisces.	219
	7:30 p.m..	E.	27	−2	14	168	...do......	K.	From α Piscium to η Arietis..	219
	7:30 p.m..	E.	36	−3	....	177	...do......	K.	Central and strongest between lucidæ Arietis and lucidæ in head of Cetus..........	219
Nov. 2	7:30 p.m..	E.	307	−2	....	87	...do......	K.	Central between π, ρ, σ Capricorni and η Capricorni........................	220
	7:30 p.m..	E.	26	−1.5	....	166	...do......	K.	Central over ο Piscium..	220
	7:30 p.m..	E.	37	−2	....	177	...do......	K.	Central between α Arietis and γ Ceti..	220
Nov. 5	7:30 p.m..	E.	311	−1	....	88	Dull......	K.	Central over θ Capricorni..	223
	7:30 p.m..	....	43	−1.5	....	180	...do......	K.	Central midway between α Ceti and μ Arietis..	223
Nov. 6	2 a.m.....	E.	43	−1.5	7	179	Brilliant..	K.	Confirmed. Breadth=distance between η and ο Piscium. E band pretty plain down to 20° above WSW horizon.	224
	2:30 a.m..	W.	148	+1	23	76	...do......	K.	Central over Regulus. Breadth=distance between Regulus and α Hydræ..........	224

6. DOES THE ZODIACAL LIGHT COME FROM ANY PART OF THE EARTH'S ATMOSPHERE?

Does the zodiacal light come from any part of the earth's atmosphere? is the problem that interests meteorology. Now, the atmosphere of the earth undoubtedly extends much farther upward from the earth's surface than is popularly supposed. It is by no means likely that it is limited to a depth of two or three hundred kilometers, even though shooting stars and auroras indicate that to be the limit of its visible effect on them; they must have penetrated it long distances before heating up to visibility and burning temperatures. Our atmosphere is apparently connected through the so-called ether of space with the entire solar system. The zodiacal light, visible near the sun at sunrise and sunset, was for a time thought to belong to the earth's atmosphere; gradually our ideas enlarged, so that we were willing to acknowledge it as a complete ring of very delicate matter, either gaseous or dusty, revolving possibly around the earth or possibly around the sun, in which latter case it becomes a portion of the solar atmosphere, giving it a delicate nebulous ring.

The preceding article and the previous observations and conclusions by Maxwell Hall seem now to settle many doubts on the subject. The fact that volcanic dust ascends to great heights and remains long in our atmosphere makes it quite plausible that the zodiacal light is simply sunlight reflected to us by a ring of dust and gaseous matter that may have emanated from the sun and the planets, or, may have been left in the space occupied by the planetary system by the original nebulous matter out of which Laplace assumed the solar system to be formed. Laplace was led, by his profound knowledge of analytical mechanics, to calculate the position of a certain plane which he called the "invariable plane of the solar system." Assuming that there is no other important planetary mass belonging to our system, he calculated that for the year 1800, so far as the planets were then known, this invariable plane had an inclination of 1° 35′ to the plane of the earth's orbit, i. e., the ecliptic of that date, and had its ascending node at 102° 57′. Owing to the great mass of the planets Jupiter and Saturn the location of this invariable plane was not very different from that of a plane midway between the orbital planes of these two planets, since the orbit of Jupiter has an inclination to the ecliptic of 1° 19′ and its ascending node is at 98° 54′, whereas the orbit of Saturn has an inclination of 2° 29′ and its ascending node is at 112° 22′. The plane of

the sun's rotation itself is inclined 7° 15′ and its node is at 73° 57′. Owing to the mutual attractions and perturbations of all the planets, their orbital planes, including that of the earth and the sun, vary continually in their relations to each other; therefore the above figures relative to the plane of the earth's orbit must slowly change; especially have they been changed by the discovery of new large planets.

Still it remains true that the invariable plane of the solar system, considered as a sort of equilibrium among the planes of the orbits of all the bodies of the solar system, will remain unchanged in absolute position, no matter whether new planets are formed or old planets broken up, so long as there be no change in the total mass of the system and no extraneous forces be brought to bear upon it. There is therefore some plausibility in Mr. Maxwell Hall's suggestion that the present zodiacal light may be reflected from a residual delicate mass revolving about the sun in a plane that nearly coincides with the invariable plane of some previous geological age. Whenever, by spectroscopic means or otherwise, physicists are able to determine the linear velocity of motion of any part of the zodiacal light, as they have done for so many delicate comets and stars, we shall be able to locate the distance of some part of the zodiacal mass from the sun and thus give greater precision to the present hypothesis. It will not surprise me to learn that the distance of this mass from the sun lies between the earth and Mars, just as the planetoids lie between Mars and Jupiter, both having a similar origin. In any case it is important to understand the relations between the zodiacal light and the earth's atmosphere, even if we do eventually class it with other considerations that have been found unimportant in the present state of meteorology.

Doubtless a slight variation in the brightness of the sun, inappreciable to measurements made in the glaring light of daytime, would become appreciable to measurements of the brightness of the zodiacal light when the sun is below the horizon. Such measurements would thus contribute to our knowledge of the influence on our earth of variations in the solar radiation. One might hope for equally good results from observations of the brightness of the lunar disk were it not for the variations to which the albedo of the latter is subjected by every variation in the lunar surface and in the light reflected from the earth to the moon. We have therefore to thank Mr. Maxwell Hall for a persistent series of observations and an argument that has brought us one step further in our knowledge of the earth's atmosphere as well as of the complex solar system.

Prof. Simon Newcomb, in his article on the zodiacal light (Encyclopædia Britannica, eleventh edition, 1911, probably revised by Prof. Newcomb shortly before his death in 1909, as it includes references to Seeliger, 1906, and Maxwell Hall, 1906), inclines to

the view that observers using the polariscope and the spectroscope may have been deceived by the presence of an aurora in the sky, and that the direct proof that we have to do with reflected sunlight is still incomplete. He agrees with the conclusions of Prof. F. R. Moulton, of Chicago, that if the small particles circulate around the sun in nearly circular orbits immediately outside the earth, then the perturbations by the earth in the motions of the particles will result in their retardation in that part of the orbit nearest the earth, and therefore they will be always more numerous in a given space in this part of the orbit than in any other. This view seems to account for the special intensification of the light when the material reflects it at the proper angle. Newcomb leans to the belief that the zodiacal matter is an exceedingly tenuous gas rather than small solid particles, and that its axis of revolution is located between the axis of the sun's equator and that of the invariable plane of the solar system.

The respective inclinations 7° 15′ and 1° 35′ of these planes to the ecliptic, taken in consideration with the longitudes of their nodes 73° 57′ and 102° 57′, show a reasonable agreement with the inclination of the zodiacal light 1° 45′ and its ascending node 105½°.

[C. A., ED.]

7. FREE AIR DATA AT MOUNT WEATHER FOR APRIL, MAY, JUNE, 1913.

By the AERIAL SECTION.—WM. R. BLAIR, in charge.

[Dated November 5, 1913.]

During this period 29 free air observations were made, all by means of kites. Observations were made on every occasion that gave promise of a 24 or more hour series and on "international" days. On some occasions one kite flight only (on others more) was possible. The series of May 10 and 11 began at $6^h\ 35^m$ a. m. of the 10th and continued until midnight of the 11th, or 41⅓ hours. The mean of the highest altitudes reached in the flights of this quarter is 3,200 meters above sea level.

Whenever three or more successive flights have been made, a chart of the free air isotherms has been constructed. Two partial series, besides the long series mentioned, have been charted. Continuing the numbering of figures from the discussion of the last three months' data, figure 68 shows the free air isotherms observed in the six observations of April 4. Figures 69*a* and 69*b* show the free air isotherms of the long series of May 10 and 11, while in figures 70 and 71, 72, 73, and 74 the temperature, absolute humidity, wind direction and velocity, and the atmospheric electric potentials at levels 500 meters apart are charted. Figure 75 shows the free air isotherms observed in the three observations of June 12, 1913. On April 4 and on June 12 there were some clouds at altitudes above those reached by the kites. On May 10 and 11 there was intermittent cloudiness—the sky never being more than four-tenths covered—from the beginning of the series until 3 p. m. of the second day. These clouds were low, their bases being successively at the 1 kilometer, the $1\frac{8}{10}$ kilometers, and higher levels. The isothermal charts for these dates are characteristic. The isotherms in figures 68 and 75 are fairly smooth curves. Those shown in figures 69*a* and 69*b* change level frequently and abruptly in the region of cloud formation and dissipation.

Temperature data for two somewhat overlapping 24-hour periods have been taken from the observations of May 10 and 11. Tables XIX and XX show for these two periods, respectively, the corrected and smoothed hourly temperatures and the departures of the latter from the mean temperature of the day at the different levels. The curves representing the diurnal variation of temperature at different levels in each of these periods (figs. 70 and 71, respectively) differ

slightly in that the level of least variation from the mean is at 1.5 kilometers in the first and at 2 kilometers in the second. Both sets of curves show, level for level, the same general types of departure from the mean temperatures, and are like the temperature curves of preceding 24-hour series of temperature observations. The curves of absolute humidity (fig. 72) show little variation in the value of this element throughout the 41 hours. They are neither smoothed nor corrected for 24-hour changes. The winds were remarkably steady at all levels throughout the series of May 10 and 11 and, as shown in figure 73, began to change direction and to decrease in velocity almost simultaneously at the three lower levels. The electric potentials are higher on the second than on the first day of the series of observations, and the curves (fig. 74) show the usual nocturnal maximum.

Tables follow which show all data obtained in each of the 29 observations of the period, together with notes on the weather conditions.

TABLE XIX.—*Free air temperatures at Mount Weather, 9.30 a. m., May 10, to 9.30 a. m., May 11, 1913.*

Hour.	526 m. (surface).			1,000 m.			1,500 m.		
	Corrected.	Smoothed.	Departures.	Corrected.	Smoothed.	Departures.	Corrected.	Smoothed.	Departures.
	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.
1 a. m.	2.1	1.9	−2.9	−2.3	−2.1	−0.9	−7.9	−7.3	−1.1
2 a. m.	1.1	1.5	−3.3	−1.6	−1.8	−0.6	−6.4	−6.0	+0.2
3 a. m.	1.3	1.1	−3.7	−1.5	−2.0	−0.8	−3.7	−5.9	+0.3
4 a. m.	0.9	0.9	−3.9	−2.9	−2.7	−1.5	−7.7	−6.6	−0.4
5 a. m.	0.5	0.5	−4.3	−3.8	−3.4	−2.2	−8.5	−7.7	−1.5
6 a. m.	0.2	0.8	−4.0	−3.6	−3.1	−1.9	−6.9	−6.4	−0.2
7 a. m.	1.6	1.8	−3.0	−2.0	−2.9	−1.7	−3.9	−6.1	+0.1
8 a. m.	3.5	3.2	−1.6	−3.0	−2.7	−1.5	−7.4	−6.0	+0.2
9 a. m.	4.4	4.5	−0.3	−3.2	−3.3	−2.1	−6.8	−7.6	−1.4
10 a. m.	5.6	5.7	+0.9	−3.7	−2.7	−1.5	−8.7	−6.6	−0.4
11 a. m.	7.2	6.7	+1.9	−1.1	−1.8	−0.6	−4.3	−6.4	−0.2
12 noon.	7.2	7.5	+2.7	−0.7	−1.0	+0.2	−6.2	−6.2	0.0
1 p. m.	8.1	8.1	+3.3	−1.2	−0.6	+0.6	−8.0	−6.9	−0.7
2 p. m.	8.9	9.0	+4.2	0.1	0.0	+1.2	−6.6	−6.4	−0.2
3 p. m.	9.9	9.5	+4.7	1.2	1.0	+2.2	−4.6	−5.4	+0.8
4 p. m.	9.7	9.6	+4.8	1.7	1.6	+2.8	−4.9	−4.5	+1.7
5 p. m.	9.2	9.1	+4.3	1.8	1.7	+2.9	−4.0	−4.6	+1.6
6 p. m.	8.4	8.2	+3.4	1.7	1.5	+2.7	−5.0	−4.9	+1.3
7 p. m.	7.0	7.0	+2.2	0.9	0.8	+2.0	−5.8	−5.7	+0.5
8 p. m.	5.5	5.7	+0.9	−0.1	0.2	+1.4	−6.2	−6.0	+0.2
9 p. m.	4.5	4.6	−0.2	−0.1	−0.2	+1.0	−5.9	−6.0	+0.2
10 p. m.	3.8	3.9	−0.9	−0.5	−0.7	+0.5	−5.8	−6.1	+0.1
11 p. m.	3.3	3.2	−1.6	−1.4	−1.4	−0.2	−6.6	−6.7	−0.5
12 midnight.	2.6	2.7	−2.1	−2.3	−2.0	−0.8	−7.6	−7.4	−1.2
Means.	4.8			−1.2			−6.2		

Hour.	2,000 m.			2,500 m.			3,000 m.		
	Corrected.	Smoothed.	Departures.	Corrected.	Smoothed.	Departures.	Corrected.	Smoothed.	Departures.
	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.
1 a. m.	−11.5	−10.2	−1.5	−12.1	−10.5	−0.7	−12.6	−11.5	−0.3
2 a. m.	− 9.1	− 8.5	+0.2	− 9.8	− 9.7	+0.1	−11.6	−11.2	0.0
3 a. m.	− 4.8	− 6.8	+1.9	− 7.1	− 8.4	+1.4	− 9.3	−10.3	+0.9
4 a. m.	− 6.5	− 7.0	+1.7	− 8.4	− 8.7	+1.1	− 9.9	−10.2	+1.0
5 a. m.	− 9.7	− 7.3	+1.4	−10.6	− 8.7	+1.1	−11.4	− 9.9	+1.3
6 a. m.	− 5.6	− 6.3	+2.4	− 7.1	− 7.5	+2.3	− 8.5	− 9.1	+2.1
7 a. m.	− 3.6	− 5.5	+3.2	− 4.9	− 6.6	+3.2	− 7.5	− 8.7	+2.5
8 a. m.	− 7.3	− 6.3	+2.4	− 7.7	− 7.3	+2.5	−10.1	− 9.6	+1.6
9 a. m.	− 8.0	− 8.6	+0.1	− 9.3	− 9.2	+0.6	−11.2	−11.0	+0.2
10 a. m.	−10.4	− 8.0	+0.7	−10.6	− 9.1	+0.7	−11.8	−11.2	0.0
11 a. m.	− 5.6	− 7.9	+0.8	− 7.3	− 8.5	+1.3	−10.7	−11.3	−0.1
12 noon.	− 7.8	− 8.8	−0.1	− 7.5	− 9.4	+0.4	−11.5	−11.5	−0.3
1 p. m.	−13.0	−10.6	−1.9	−13.4	−10.3	−0.5	−12.2	−11.8	−0.6
2 p. m.	−11.0	−10.4	−1.7	−10.1	−10.3	−0.5	−11.8	−11.5	−0.3
3 p. m.	− 7.2	− 9.8	−1.1	− 7.4	−10.2	−0.4	−10.6	−12.1	−0.9
4 p. m.	−11.2	− 9.3	−0 6	−13.1	−11.3	−1.5	−14.0	−13.1	−1.9
5 p. m.	− 9.4	−10.1	−1.4	−13.3	−12.3	−2.5	−14.6	−13.4	−2.2
6 p. m.	− 9.7	− 9.9	−1.2	−10.4	−11.5	−1.7	−11.5	−12.5	−1.3
7 p. m.	−10.6	−10.6	−1.9	−10.7	−11.0	−1.2	−11.3	−12.0	−0.8
8 p. m.	−11.4	−10.7	−2.0	−12.0	−11.6	−1.8	−13.2	−12.6	−1.4
9 p. m.	−10.2	− 9.8	−1.1	−12.0	−11.6	−1.8	−13.4	−12.7	−1.5
10 p. m.	− 7.7	− 8.9	−0.2	−10.8	−10.7	−0.9	−11.4	−11.5	−0.3
11 p. m.	− 8.9	− 8.8	−0.1	− 9.2	− 9.9	−0.1	− 9.7	−10.5	+0.7
12 midnight.	− 9.9	−10.1	−1.4	− 9.6	−10.3	−0.5	−10.4	−10.9	+0.3
Means.	− 8.7			− 9.8			−11.2		

TABLE XX.—*Free air temperatures at Mount Weather, 8.30 p. m., May 10, to 8.30 p. m., May 11, 1913.*

Hour.	526 m. (surface). Corrected.	Smoothed.	Departures.	1,000 m. Corrected.	Smoothed.	Departures.	1,500 m. Corrected.	Smoothed.	Departures.
	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.
1 a. m.	2.9	2.8	−2.6	−1.4	−1.1	−0.6	−7.2	−6.6	−1.0
2 a. m.	1.8	2.2	−3.2	−0.8	−1.1	−0.6	−6.0	−5.6	0.0
3 a. m.	1.8	1.6	−3.8	−1.0	−1.4	−0.9	−3.5	−5.8	−0.2
4 a. m.	1.3	1.3	−4.1	−2.5	−2.4	−1.9	−7.8	−6.8	−1.2
5 a. m.	0.7	0.8	−4.6	−3.7	−3.3	−2.8	−9.0	−8.1	−2.5
6 a. m.	0.3	0.9	−4.9	−3.6	−3.2	−2.7	−7.6	−7.2	−1.6
7 a. m.	1.6	1.8	−3.6	−2.3	−3.1	−2.6	−4.9	−7.0	−1.4
8 a. m.	3.4	3.1	−2.3	−3.4	−3.2	−2.7	−8.6	−7.[illegible]	−1.6
9 a. m.	4.2	4.4	−1.0	−3.8	−3.6	−3.1	−8.2	−8.0	−2.4
10 a. m.	5.5	5.5	+0.1	−3.7	−3.4	−2.9	−7.2	−7.3	−1.7
11 a. m.	6.8	6.7	+1.3	−2.6	−2.4	−1.9	−6.4	−6.5	−0.9
12 noon	7.7	7.8	+2.4	−0.9	−1.1	−0.6	−5.8	−6.1	−0.5
1 p. m.	8.9	8.8	+3.4	0.2	0.2	+0.7	−6.1	−5.6	0.0
2 p. m.	9.8	9.8	+4.4	1.3	1.2	+1.7	−4.9	−4.9	+0.7
3 p. m.	10.6	10.3	+4.9	2.2	2.1	+2.6	−3.8	−3.9	+1.7
4 p. m.	10.5	10.5	+5.1	2.8	2.7	+3.2	−3.1	−3.4	+2.2
5 p. m.	10.5	10.1	+4.7	3.0	3.0	+3.5	−3.3	−3.3	+2.3
6 p. m.	9.3	9.2	+3.8	3.2	2.9	+3.4	−3.5	−3.4	+2.2
7 p. m.	7.7	8.1	+2.7	2.6	2.6	+3.1	−3.3	−3.6	+2.0
8 p. m.	7.2	6.9	+1.5	1.9	2.0	+2.5	−3.9	−3.8	+1.8
9 p. m.	5.8	6.0	+0.6	1.5	1.5	+2.0	−4.2	−4.1	+1.5
10 p. m.	5.0	5.1	−0.3	1.0	0.8	+1.3	−4.3	−4.6	+1.0
11 p. m.	4.4	4.3	−1.1	−0.1	−0.1	+0.4	−5.4	−5.4	+0.2
12 midnight	3.6	3.6	−1.8	−1.2	−0.9	−0.4	−6.6	−6.4	−0.8
Means	5.4	....	....	−0.5	....	....	−5.6	....	....

Hour.	2,000 m. Corrected.	Smoothed.	Departures.	2,500 m. Corrected.	Smoothed.	Departures.	3,000 m. Corrected.	Smoothed.	Departures.
	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.
1 a. m.	−12.0	−10.6	−1.7	−12.9	−11.5	−0.7	−14.0	−12.9	−0.3
2 a. m.	− 9.8	− 9.2	−0.3	−11.0	−10.7	+0.1	−13.0	−12.6	0.0
3 a. m.	− 5.7	− 7.7	+1.2	− 8.3	− 9.6	+1.2	−10.7	−11.7	+0.9
4 a. m.	− 7.7	− 8.2	+0.7	− 9.6	−10.0	+0.8	−11.4	−11.7	+0.9
5 a. m.	−11.1	− 8.7	+0.2	−12.0	−10.1	+0.7	−12.9	−11.4	+1.2
6 a. m.	− 7.2	− 7.9	+1.0	− 8.6	− 9.1	+1.7	−10.0	−10.6	+2.0
7 a. m.	− 5.5	− 7.4	+1.5	− 6.6	− 8.2	+2.6	− 9.0	−10.2	+2.4
8 a. m.	− 9.4	− 8.4	+0.5	− 9.5	− 9.1	+1.7	−11.6	−11.1	+1.5
9 a. m.	−10.3	− 9.6	−0.7	−11.3	−10.1	+0.7	−12.7	−12.2	+0.4
10 a. m.	− 9.0	− 9.1	−0.2	− 9.6	− 9.9	+0.9	−12.3	−12.2	+0.4
11 a. m.	− 8.0	− 8.5	+0.4	− 8.7	− 9.7	+1.1	−11.7	−12.5	+0.1
12 noon	− 8.6	− 9.5	−0.6	−10.7	−11.1	−0.3	−13.6	−13.4	−0.8
1 p. m.	−12.0	−10.6	−1.7	−13.9	−12.8	−2.0	−15.0	−14.3	−1.7
2 p. m.	−11.2	−10.9	−2.0	−13.7	−13.3	−2.5	−14.4	−14.0	−1.4
3 p. m.	− 9.4	− 9.2	−0.3	−12.2	−11.7	−0.9	−12.6	−13.2	−0.6
4 p. m.	− 7.1	− 8.2	+0.7	− 9.3	−11.2	−0.4	−12.7	−13.3	−0.7
5 p. m.	− 8.2	− 8.0	+0.9	−12.0	−11.2	−0.4	−14.6	−14.1	−1.5
6 p. m.	− 8.6	− 8.3	+0.6	−12.3	−11.5	−0.7	−14.9	−14.1	−1.5
7 p. m.	− 8.1	− 8.6	+0.3	−10.2	−11.4	−0.6	−12.9	−13.2	−0.6
8 p. m.	− 9.1	− 9.0	−0.1	−11.8	−11.5	−0.7	−11.7	−13.1	−0.5
9 p. m.	− 9.7	− 8.7	+0.2	−12.5	−11.9	−1.1	−14.6	−13.0	−0.4
10 p. m.	− 7.4	− 8.7	+0.2	−11.5	−11.3	−0.5	−12.7	−12.8	−0.2
11 p. m.	− 8.9	− 8.8	+0.1	−10.0	−10.7	+0.1	−11.0	−11.8	+0.2
12 midnight	−10.1	−10.3	−1.4	−10.5	−11.1	−0.3	−11.8	−12.3	+0.2
Means	− 8.9	....	....	−10.8	....	....	−12.6	....	....

Results of free-air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P.D. kite and earth.
				Direction.	Velocity.				Rel.	Abs.	Dir.	Vel.	
Apr. 4, 1913:													
First flight—	*mm.*	*C.*	*%*		*m.p.s.*	*m.*	*mm.*	*C.*	*%*	*g/cu.m.*		*m.p.s.*	*Volts.*
6.45 a. m..	715.9	16.0	75	s.	6.3	526	715.9	16.0	75	10.1	s.	6.3	......
6.48 a. m..	715.9	16.0	75	s.	5.8	696	701.9	16.3	79	10.9	wsw.	......	0
6.50 a. m..	715.9	16.0	75	s.	5.4	817	691.9	18.1	72	11.0	wsw.	15.1	0
6.52 a. m..	715.9	16.0	75	s.	5.4	1.012	676.4	17.7	68	10.2	wsw.	15.1	0
6.59 a. m..	715.9	16.0	75	s.	4.9	1,095	669.9	18.1	59	9.0	wsw.	20.3	30
7.09 a. m..	715.9	16.0	76	s.	4.9	1.675	625.8	12.2	71	7.6	w.	18.5	170
7.30 a. m..	716.0	16.0	77	s.	4.9	2.498	566.7	5.4	75	5.2	wsw.	18.5	170
7.53 a. m..	716.1	16.0	77	s.	7.6	3,178	521.1	−0.2	59	2.8	wsw.	17.3	425
8.02 a. m..	716.1	16.0	77	s.	5.8	3.076	528.0	−0.2	59	2.8	sw.	16.1	425
8.18 a. m..	716.1	16.0	77	s.	7.2	3.888	475.8	−5.5	68	2.1	sw.	24.2	780
8.33 a. m..	716.1	15.8	79	s.	8.5	3,623	491.4	−2.8	52	2.0	sw.	......	670
8.35 a. m..	716.1	15.8	79	s.	8.0	3,582	493.9	−3.7	52	1.9	sw.	......	625
8.36 a. m..	716.1	15.8	79	s.	8.0	3,517	498.0	−2.8	49	1.9	sw.	......	600
8.42 a. m..	716.1	15.9	78	s.	7.2	3.409	504.8	−2.9	40	1.5	sw.	21.8	550
8.43 a. m..	716.1	16.0	78	s.	7.2	3,396	505.6	−2.0	38	1.6	sw.	21.8	540
8.44 a. m..	716.1	16.0	78	s.	7.6	3.372	507.2	−2.6	37	1.5	sw.	20.4	460
8.47 a. m..	716.1	16.0	78	s.	7.6	3.344	509.0	−1.9	36	1.5	sw.	21.7	460
8.48 a. m..	716.1	16.0	78	s.	7.6	3,304	511.5	−2.6	36	1.4	sw.	18.8	460
8.56 a. m..	716.1	16.1	79	s.	7.2	3.042	528.8	−1.9	49	2.0	wsw.	17.5	440
9.14 a. m..	716.0	16.2	78	s.	6.7	2.397	572.7	3.7	73	4.5	wsw.	16.1	380
9.16 a. m..	716.0	16.2	77	s.	5.8	2.273	581.6	3.7	76	4.7	wsw.	14.5	340
9.28 a. m..	716.0	16.2	77	s.	6.3	1.697	623.7	9.2	75	6.7	wsw.	17.6	170
9.43 a. m..	715.9	16.6	80	s.	6.7	1,052	673.2	16.3	60	8.2	wsw.	......	0
9.48 a. m..	715.9	16.6	79	s.	5.8	629	707.4	17.6	74	11.0	wsw.	......	0
9.49 a. m..	715.9	16.6	78	s.	5.8	588	710.8	14.8	76	9.5	wsw.	......	0
9.50 a. m..	715.8	16.6	78	s.	5.8	526	715.8	16.6	78	10.9	s.	5.8	......
Second flight—													
10.22 a. m..	715.8	17.7	78	s.	7.6	526	715.8	17.7	78	11.7	s.	7.6	......
10.26 a. m..	715.8	17.5	77	s.	8.0	610	708.9	15.6	79	10.4	sw.	......	0
10.27 a. m..	715.8	17.4	77	s.	8.0	799	693.4	18.2	70	10.8	sw.	18.5	0
10.34 a. m..	715.7	18.0	76	s.	8.0	1,018	675.8	17.0	58	8.3	sw.	18.7	0
10.57 a. m..	715.7	18.1	76	s.	8.9	2 046	598.2	9.6	59	5.4	sw.	20.3	340
10.58 a. m..	715.7	18.1	76	s.	8.9	2.163	590.0	9.6	64	5.8	sw.	16.9	390
11.01 a. m..	715.7	18.0	77	s.	7.2	2.305	580.0	8.2	66	5.5	sw.	16.8	410
11.03 a. m..	715.7	18.0	76	s.	7.2	2,419	572.1	7.4	63	5.0	sw.	16.8	390
11.04 a. m..	715.7	18.0	76	s.	7.6	2.449	570.1	8.2	51	4.2	sw.	18.5	380
11.13 a. m..	715.5	18.1	76	s.	7.6	2.796	546.4	7.6	30	2.4	sw.	20.5	545
11.32 a. m..	715.3	18.2	76	s.	8.0	3.462	502.6	−1.0	22	1.0	sw.	29.4	780
12.04 p. m..	714.9	18.6	78	s.	9.4	2.608	557.6	5.6	20	1.4	wsw.	22.1	330
12.05 p. m..	714.9	18.6	78	s.	8.0	2 594	558.5	6.0	21	1.5	wsw.	20.1	330
12.07 p. m..	714.9	18.7	76	s.	8.0	2.594	558.5	5.5	23	1.6	wsw.	23.5	330
12.11 p. m..	714.9	18.8	74	s.	8.0	2,499	565.1	5.5	26	1.8	wsw.	21.5	330
12.12 p. m..	714.8	18.8	74	s.	8.9	2,471	567.1	5.1	28	1.9	wsw.	21.5	320
12.30 p. m..	714.6	19.2	76	s.	7.6	1,689	623.0	10.4	60	5.7	wsw.	20.4	0
12.41 p. m..	714.5	19.5	71	s.	9.4	1,197	660.5	14.1	54	6.5	sw.	19.1	0
12.42 p. m..	714.4	19.6	71	s.	8.5	1,084	669.2	15.2	57	7.3	sw.	19.1	0
12.44 p. m..	714.4	19.6	71	s.	10.3	987	676.8	14.0	71	8.5	sw.	13.9	0
12.45 p. m..	714.4	19.5	70	s.	10.3	962	679.0	14.6	73	9.1	sw.	13.0	0
12.46 p. m..	714.4	19.5	70	s.	10.3	962	679.0	14.0	78	9.3	sw.	13.0	0
12.47 p. m..	714.4	19.4	69	s.	10.3	962	679.0	15.5	70	9.2	sw.	13.0	0
12.48 p. m..	714.4	19.4	69	s.	10.3	892	684.5	14.6	78	9.7	sw.	15.4	0
12.56 p. m..	714.3	18.9	74	s.	11.6	526	714.3	18.9	74	11.9	s.	11.6	......

April 4, 1913.—First flight: Five kites were used; lifting surface, 31.5 sq. m. Wire out, 6,000 m.; at maximum altitude, 5,750 m.

There were 10/10 St.-Cu. from the west-southwest.

At 8 a. m. low pressure (752 mm.) was central over Lake Huron. High pressure was central over the Bermudas (775 mm.), and over the lower St. Lawrence Valley (770 mm.).

Second flight: Four kites were used; lifting surface, 24.2 sq. m. Wire out, 5,000 m.; at maximum altitude, 4,900 m.

There were 10/10 St.-Cu. from the west-southwest.

Results of free-air observations—Continued.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Direction.	Velocity.				Rel.	Abs.	Dir.	Vel.	
Apr. 4, 1913—Continued.													
Third flight—	*mm.*	*C.*	%		*m.p.s.*	*m.*	*mm.*	*C.*	%	*g/cu.m.*		*m.p.s.*	*Volts.*
1.22 p. m.	714.1	19.9	66	s.	4.9	526	714.1	19.9	66	11.2	s.	4.9	......
1.36 p. m.	714.0	20.5	66	s.	10.3	932	681.0	15.9	84	11.3	ssw.	16.6	0
1.53 p. m.	713.9	20.1	66	s.	10.7	1,586	630.3	12.2	72	7.7	sw.	20.6	0
2.08 p. m.	713.9	20.2	68	s.	11.2	2,335	576.0	5.6	80	5.6	wsw.	17.6	170
2.14 p. m.	713.9	20.1	68	s.	7.6	2,480	566.0	7.3	68	5.3	wsw.	23.6	170
2.23 p. m.	713.9	20.3	68	s.	10.3	2,866	539.9	4.4	70	4.5	wsw.	24.5	450
2.27 p. m.	713.9	20.4	68	s.	10.7	2,946	534.6	4.4	69	4.5	wsw.	26.2	515
2.37 p. m.	713.8	20.4	67	s.	10.7	3,219	516.3	0.3	68	3.4	wsw.	......	540
2.56 p. m.	713.8	20.5	64	s.	9.4	2,862	539.1	2.5	73	4.2	wsw.	23.9	340
2.57 p. m.	713.8	20.5	64	s.	9.4	2,777	544.5	1.7	76	4.1	wsw.	21.8	290
3.01 p. m.	713.8	20.5	63	s.	7.2	2,672	551.9	3.2	76	4.6	wsw.	22.6	220
3.03 p. m.	713.8	20.5	62	s.	9.4	2,576	558.5	1.9	84	4.6	wsw.	21.8	170
3.29 p. m.	713.6	21.0	60	s.	11.6	1,593	629.2	10.1	76	7.1	sw.	15.7	0
3.40 p. m.	713.5	21.2	59	s.	8.0	979	677.7	15.0	79	10.0	sw.	16.8	0
3.48 p. m.	713.5	21.0	60	s.	12.5	526	713.5	21.0	60	10.9	s.	12.5	......
Fourth flight—													
4.34 p. m.	713.3	21.4	56	ssw.	9.4	526	713.3	21.4	56	10.4	ssw.	9.4	......
4.44 p. m.	713.3	21.0	60	ssw.	6.7	1,026	673.0	17.4	57	8.4	sw.	18.2	0
4.58 p. m.	713.3	21.2	56	ssw.	10.3	1,690	622.5	12.1	60	6.4	wsw.	17.7	0
5.15 p. m.	713.3	21.4	57	s.	7.6	3,166	520.1	−1.0	69	3.1	wsw.	......	270
5.25 p. m.	713.3	21.2	52	s.	10.3	3,600	491.1	−3.0	64	2.4	wsw.	......	460
5.34 p. m.	713.3	21.3	57	s.	8.9	3,535	493.9	−2.8	63	2.4	wsw.	......	450
5.36 p. m.	713.3	21.3	57	s.	8.9	3,475	497.6	−3.5	63	2.3	wsw.	......	430
5.37 p. m.	713.3	21.2	57	s.	6.7	3,459	498.6	−2.9	64	2.5	wsw.	......	420
5.41 p. m.	713.3	21.1	57	s.	8.5	3,382	503.3	−5.2	68	2.2	wsw.	......	340
6.02 p. m.	713.3	20.4	63	s.	10.7	2,669	550.8	−1.2	74	3.3	wsw.	19.0	160
6.23 p. m.	713.4	20.4	63	s.	9.4	1,646	624.7	7.8	71	5.8	sw.	13.0	0
6.35 p. m.	713.4	20.0	62	s.	9.4	962	678.0	14.0	67	8.0	sw.	17.5	0
6.41 p. m.	713.4	19.8	62	s.	7.2	526	713.4	19.8	62	10.5	s.	7.2	......
Fifth flight—													
7.06 p. m.	713.5	19.8	62	s.	7.2	526	713.5	19.8	62	10.5	s.	7.2	......
7.15 p. m.	713.5	19.8	62	s.	8.0	1,010	674.5	16.8	67	9.5	s.	16.5	0
7.25 p. m.	713.5	19.6	62	s.	9.4	1,556	632.4	11.6	71	7.3	sw.	15.1	0
7.27 p. m.	713.5	19.6	62	s.	9.4	1,556	632.4	11.8	70	7.3	sw.	15.1	0
7.28 p. m.	713.5	19.6	62	s.	8.9	1,543	633.4	11.3	71	7.2	sw.	15.1	0
7.30 p. m.	713.6	19.6	62	s.	7.6	1,572	631.3	11.4	72	7.3	sw.	16.1	0
7.32 p. m.	713.6	19.5	62	s.	7.6	1,683	622.8	10.6	73	7.1	sw.	15.2	0
7.50 p. m.	713.6	19.5	63	s.	8.0	2,387	571.7	0.9	95	4.9	sw.	16.1	0
7.57 p. m.	713.6	19.4	64	s.	8.0	2,570	558.9	0.9	88	4.5	sw.	16.9	60
8.14 p. m.	713.6	19.3	64	ssw.	7.6	3,044	525.8	−4.3	80	2.7	sw.	......	170
8.17 p. m.	713.6	19.3	64	ssw.	6.3	2,992	528.4	−4.3	83	2.9	sw.	......	160
8.45 p. m.	713.7	19.2	64	ssw.	5.4	2,356	572.7	−0.2	85	4.0	wsw.	14.3	0
9.08 p. m.	713.7	19.0	66	ssw.	5.4	1,490	636.7	8.5	86	7.3	sw.	12.6	0
9.20 p. m.	713.8	18.9	68	sw.	6.7	898	683.4	13.9	74	8.8	sw.	10.4	170
9.30 p. m.	713.8	18.4	71	sw.	4.5	526	713.8	18.4	71	11.1	sw.	4.5	......

Third flight: Four kites were used; lifting surface, 24.2 sq. m. Wire out, 5,000 m. at maximum altitude, 4,800 m.

There were 10/10 St.-Cu. from the west-southwest till about 1.50 p. m.; 6/10 A.-St. and 4/10 St.-Cu. from the west-southwest till about 3.40 p. m.; thereafter there were 4/10 Ci. and 4/10 St.-Cu. from the west-southwest.

Fourth flight: Four kites were used; lifting surface, 24.2 sq. m. Wire out, 4,500 m.; at maximum altitude, 4,250 m.

Ci. from the west and St.-Cu. from the southwest varied from 7/10 to 8/10.

Fifth flight: Four kites were used; lifting surface, 24.2 sq. m. Wire out, 5,000 m., at maximum altitude.

There were 3/10 Ci. from the west and 4/10 St.-Cu. from the southwest till about 7.45 p. m.; thereafter, St.-Cu. from the southwest varied from 8/10 to 10/10.

Results of free-air observations—Continued.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P.D. kite and earth.
				Direction.	Velocity.				Rel.	Abs.	Dir.	Vel.	
Apr. 4, 1913—Continued.													
Sixth flight—	*mm.*	*C.*	%		*m.p.s.*	*m.*	*mm.*	*C.*	%	*g/cu.m.*		*m.p.s.*	*Volts.*
10.33 p. m.	713.9	13.4	87	nw.	13.4	526	713.9	13.4	87	10.0	nw.	13.4	......
10.37 p. m.	713.9	12.7	93	nw.	11.6	980	676.2	10.6	90	8.7	nw.	21.8	2,600
10.44 p. m.	713.9	12.0	100	nw.	16.5	1,403	642.5	8.6	84	7.2	nw.	25.5	......
11.10 p. m.	713.9	11.8	100	nw.	14.3	924	680.6	7.9	96	7.8	nw.	......	......
11.22 p. m.	713.9	11.8	99	nw.	15.2	526	713.9	11.8	99	10.3	nw.	15.2	......
May 5, 1913:													
1.34 p. m.	722.6	25.1	49	sse.	5.8	526	722.6	25.1	49	11.2	sse.	5.8	......
1.46 p. m.	722.5	25.4	50	sse.	6.7	830	697.9	22.2	42	8.2	sse.	9.2	0
1.47 p. m.	722.5	25.4	50	sse.	6.7	845	696.8	23.1	41	8.4	sse.	9.2	0
1.49 p. m.	722.5	25.4	50	sse.	8.0	845	696.8	21.4	41	7.6	sse.	7.6	0
2.45 p. m.	721.8	25.4	45	sse.	5.8	863	694.6	24.1	26	5.6	s.	5.2	0
2.50 p. m.	721.7	25.4	42	sse.	5.8	781	701.2	24.0	26	5.6	s.	6.4	0
2.51 p. m.	721.7	25.4	41	sse.	6.7	710	706.8	23.0	31	6.3	s.	6.4	0
2.52 p. m.	721.7	25.4	41	sse.	6.7	615	714.5	24.0	33	7.1	s.	......	0
2.53 p. m.	721.7	25.4	40	sse.	6.7	526	721.7	25.4	40	9.3	sse.	6.7	......
May 6, 1913:													
10.08 a. m.	717.6	21.0	56	wnw.	7.2	526	717.6	21.0	56	10.2	wnw.	7.2	......
10.11 a. m.	717.5	20.8	55	wnw.	7.2	632	708.9	20.7	48	8.6	nw	8.8	0
10.14 a. m.	717.5	20.6	54	wnw.	6.7	700	703.4	20.9	47	8.5	nw.	8.8	0
10.16 a. m.	717.5	20.6	54	wnw.	6.7	852	691.2	20.5	45	7.9	nw.	......	0
10.43 a. m.	717.4	21.8	57	wnw.	7.2	1,154	667.3	19.1	38	6.2	nw.	11.6	0
11.56 a. m.	716.9	23.5	48	wnw.	10.3	1,671	627.8	14.8	36	4.5	nw.	......	......
12.19 p. m.	716.8	23.6	47	wnw.	8.5	981	680.3	18.6	44	6.9	nw.	13.8	0
12.30 p. m.	716.8	24.6	44	wnw.	8.5	526	716.8	24.6	44	9.8	wnw.	8.5	......

Sixth flight: Two kites were used; lifting surface, 11.6 sq. m. Wire out, 1,600 m.; at maximum altitude, 1,250 m.

There were 10/10 St.-Cu. from the southwest. Rain began at 10.36 p. m.

Two kites were used; lifting surface, 14.6 sq. m. Wire out, 900 m.; at maximum altitude, 600 m.

There were 7/10 Ci. from the west-northwest till 2.30 p. m.; thereafter, 7/10 Ci. and Ci.-Cu. from the west-northwest.

High pressure (772 mm.), central off Nova Scotia, covered the Atlantic Coast States. Pressure was low over the Mississippi Valley, with centers over Ontario (762 mm.) and over Kansas and Oklahoma (762 mm.).

Five kites were used; lifting surface, 34.0 sq. m. Wire out, 4,100 m.; at maximum altitude, 2,350 m.

There were 2/10 A.-Cu. from the west-northwest and dense haze.

High pressure (774 mm.) was central over the upper Missouri Valley. Low pressure (758 mm.) was central over Quebec.

Results of free-air observations—Continued.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind. Direction.	Wind. Velocity.	Height	Pressure.	Temperature.	Humidity. Rel.	Humidity. Abs.	Wind. Dir.	Wind. Vel.	P.D. kite and earth.
May 7, 1913:	*mm.*	*C.*	*%*		*m.p.s.*	*m.*	*mm.*	*C.*	*%*	*g/cu.m.*		*m.p.s.*	*Volts.*
8.15 a.m..	717.7	12.0	49	nnw.	7.2	526	717.7	12.0	49	5.2	nnw.	7.2	......
8.27 a.m..	717.7	12.0	46	nnw.	8.9	826	692.4	8.2	55	4.6	nnw.	12.9	0
8.52 a.m..	717.7	12.3	51	nnw.	8.5	1,584	631.5	5.3	82	5.7	nw.	9.4	540
8.59 a.m..	717.7	12.1	48	nnw.	8.5	1,986	601.2	6.2	79	5.8	wnw.	11.8	810
9.17 a.m..	717.8	12.3	52	nnw.	9.8	2,663	553.4	1.2	81	4.3	w.	13.3	1,280
9.43 a.m..	717.8	13.6	45	nnw.	8.5	3,449	501.2	− 7.3	97	2.6	w.	14.9	1,550
10.27 a.m..	717.9	13.2	46	nnw.	7.6	4,088	460.8	−11.9	93	1.7	w.	......	1,685
10.53 a.m..	718.0	13.6	43	nnw.	8.0	3,316	508.7	− 7.7	95	2.5	w.	......	1,240
11.12 a.m..	717.9	13.4	39	nnw.	9.4	2,664	552.4	− 0.5	69	3.2	wnw.	......	730
11.20 a.m..	717.9	13.4	45	nnw.	7.6	2,514	562.9	− 0.5	72	3.3	wnw.	12.2	630
11.28 a.m..	717.9	13.3	46	nnw.	7.6	2,094	593.0	3.3	72	4.4	wnw.	13.4	420
11.35 a.m..	717.8	13.4	41	nnw.	8.0	1,939	604.3	3.3	77	4.7	nw.	13.1	400
11.37 a.m..	717.8	13.4	40	nnw.	8.9	1,749	618.8	2.5	78	4.5	nw.	11.0	360
11.41 a.m..	717.8	13.4	38	nnw.	8.5	1,447	642.2	3.3	52	3.1	nw.	15.1	300
11.45 a.m..	717.8	13.4	38	nnw.	8.0	1,406	645.4	4.3	46	3.0	nw.	12.4	260
11.47 a.m..	717.8	13.5	38	nnw.	8.0	1,377	647.6	3.6	45	2.8	nw.	12.8	250
11.58 a.m..	717.7	13.6	39	nnw.	8.9	893	686.9	8.1	44	3.6	nnw.	12.2	0
12.07 p.m..	717.7	13.4	41	nnw.	7.2	526	717.7	13.4	41	4.7	nnw.	7.2	......
May 8, 1913:													
4.31 p.m..	720.2	18.1	42	se.	8.5	526	720.2	18.1	42	6.4	se.	8.5	......
4.43 p.m..	720.2	18.3	44	se.	7.2	942	685.9	14.1	43	5.2	se.	8.4	0
5.45 p.m..	720.0	16.9	41	se.	6.3	1,564	636.3	7.1	49	3.8	s.	8.0	950
6.52 p.m..	720.0	15.2	51	se.	7.2	2,218	586.9	0.3	60	3.0	ssw.	9.4	1,240
8.40 p.m..	720.1	12.9	68	se.	8.0	3,315	511.3	− 4.2	40	1.4	sw.	9.6	......
9.20 p.m..	720.2	12.4	68	se.	8.0	2,733	550.5	− 1.7	39	1.6	sw.	12.8	1,470
9.31 p.m..	720.3	12.2	73	se.	8.5	2,151	591.9	2.0	64	3.5	ssw.	9.8	1,020
9.34 p.m..	720.3	12.2	74	se.	8.0	1,984	604.1	2.0	67	3.7	ssw.	9.7	880
9.38 p.m..	720.3	12.1	75	se.	7.6	1,929	608.2	3.6	68	4.2	ssw.	10.6	890
9.59 p.m..	720.3	12.0	75	se.	8.9	1,219	663.1	10.3	59	5.6	se.	14.0	565
10.19 p.m..	720.3	11.7	78	se.	8.0	526	720.3	11.7	78	8.1	se.	8.0	......

May 7, 1913.—Seven kites were used; lifting surface, 46.1 sq. m. Wire out. 7,300 m.; at maximum altitude, 6,000 m.

Ci.-St., A.-St., and St.-Cu. from the west, varied from 10/10 to 7/10 before 11 a. m. Thereafter, there were 9/10 St.-Cu. from the west. Altitude of St.-Cu. increased from 3,700 m. at 10.01 a. m. to 4,000 m. at 10.35 a. m. The head kite was in the base of St.-Cu. at 10.01 and at 10.35 a. m.

High pressure (777 mm.), central over Lake Superior, covered the eastern United States. Low pressure (758 mm.) was central off Nova Scotia.

May 8, 1913.—Six kites were used; lifting surface, 40.8 sq. m. Wire out, 6,000 m.; at maximum altitude, 4,650 m.

There was light haze.

High pressure (773 mm.), central over Manitoba, and (771 mm.) central over the St. Lawrence Valley, covered the country east of the Rockies.

Results of free-air observations—Continued.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Humidity.		Wind.		P.D. kite and earth.
				Direction.	Velocity.				Rel.	Abs.	Dir.	Vel.	
May 9, 1913:	*mm.*	*C.*	%		*m.p.s.*	*m.*	*mm.*	*C.*	%	*g/cu.m.*		*m.p.s.*	*Volts.*
7.56 a. m.	719.8	13.9	55	w.	7.2	526	719.8	13.9	55	6.5	w.	7.2	......
8.02 a. m.	719.8	14.2	54	w.	7.6	669	707.8	13.2	55	6.3	wnw.	8.3	0
8.03 a. m.	719.8	14.2	54	w.	6.7	681	706.7	13.9	54	6.4	wnw.	8.3	0
8.19 a. m.	719.9	14.6	56	w.	6.7	912	687.8	13.0	52	5.8	wnw.	9.3	0
8.28 a. m.	719.9	15.0	58	w.	5.8	994	681.2	13.8	48	5.7	wnw.	10.5	0
9.03 a. m.	720.0	14.8	59	wnw.	6.3	1,503	641.2	11.0	41	4.1	wnw.	8.2	560
9.49 a. m.	720.0	15.4	57	wnw.	8.0	1,781	620.2	8.1	42	3.5	wnw.	8.2	730
9.59 a. m.	720.0	16.1	53	wnw.	8.0	2,834	545.2	0.2	42	2.1	w.	14.2	1,780
10.09 a. m.	720.0	16.2	53	wnw.	6.3	3,199	520.7	− 3.4	37	1.4	w.	14.7	1,550
10.27 a. m.	720.0	16.6	53	wnw.	4.9	3,374	509.6	− 6.2	37	1.1	w.	12.6	1,930
10.45 a. m.	720.0	17.3	49	wnw.	7.6	3,856	478.9	− 9.9	46	1.0	w.	19.4	2,210
10.58 a. m.	720.0	18.0	46	wnw.	4.0	4,490	440.3	−15.4	46	0.6	w.	22.6	......
11.24 a. m.	719.9	19.2	42	wnw.	7.2	3,880	476.5	−11.1	52	1.0	w.	22.4	1,530
11.43 a. m.	719.8	19.7	41	wnw.	4.9	3,355	509.6	− 4.9	50	1.6	w.	18.8	1,080
11.49 a. m.	719.8	20.0	41	wnw.	4.9	3,306	512.9	− 4.0	46	1.6	w.	18.8	1,000
11.52 a. m.	719.7	20.1	40	nnw.	4.9	3,226	518.0	− 3.1	46	1.7	w.	28.0	900
11.54 a. m.	719.7	20.2	40	nnw.	4.9	3,146	523.2	− 3.4	49	1.8	w.	17.9	780
12.01 p. m.	719.7	20.4	39	nw.	6.3	2,662	556.3	− 3.0	47	1.8	w.	13.0	540
12.03 p. m.	719.7	20.4	39	nw.	6.3	2,399	574.5	− 3.2	58	2.2	w.	......	......
12.10 p. m.	719.6	20.4	39	nw.	6.3	2,330	579.5	− 0.8	62	2.8	w.	13.2	......
3.54 p. m.	719.0	18.9	41	nw.	6.3	526	719.0	18.9	41	6.6	nw.	6.3	......
May 10, 1913:													
First flight—													
6.35 a. m.	720.2	2.7	67	nw.	14.8	526	720.2	2.7	67	3.9	nw.	14.8	......
6.57 a. m.	720.2	2.8	72	nw.	13.0	938	684.0	− 3.0	80	3.1	nnw.	16.2	900
7.00 a. m.	720.2	2.8	71	nw.	11.2	1,115	668.8	− 5.8	82	2.5	nnw.	17.6	1,110
7.02 a. m.	720.2	3.0	70	nw.	10.7	1,245	657.9	− 4.0	62	2.2	nnw.	17.6	1,060
7.04 a. m.	720.2	3.1	69	nw.	10.7	1,349	649.3	− 3.8	46	1.6	nnw.	18.5	1,010
7.14 a. m.	720.2	3.1	68	nw.	11.2	1,350	649.3	− 1.2	30	1.3	nnw.	17.6	1,010
7.22 a. m.	720.2	3.3	66	nw.	12.1	1,883	607.2	− 3.0	22	0.8	nnw.	15.4	1,430
7.30 a. m.	720.2	3.2	68	nw.	10.3	2,531	559.5	− 2.8	19	0.7	nnw.	18.5	1,840
7.53 a. m.	720.2	3.2	62	nw.	13.0	3,567	489.8	−11.1	10	0.2	nw.	......	3,550
8.19 a. m.	720.2	3.4	64	nw.	11.2	2,992	527.0	− 6.8	8	0.2	nw.	20.2	2,040
8.33 a. m.	720.1	3.7	61	nw.	8.9	2,598	554.0	− 4.9	6	0.2	nnw.	20.9	1,740
8.46 a. m.	720.1	3.4	64	nw.	10.3	2,279	577.0	− 4.9	4	0.1	nnw.	21.8	1,475
8.51 a. m.	720.1	3.9	62	nw.	9.8	2,119	588.9	− 3.9	4	0.1	nnw.	20.7	1,355
8.56 a. m.	720.1	4.4	60	nw.	9.4	1,850	609.3	− 3.8	4	0.1	nnw.	20.7	1,005
9.01 a. m.	720.1	4.8	58	nw.	10.7	1,587	630.1	− 6.8	10	0.3	nnw.	18.5	675
9.04 a. m.	720.1	4.9	56	nw.	10.7	1,533	634.4	− 5.2	10	0.3	nnw.	16.8	665
9.06 a. m.	720.1	4.9	55	nw.	9.4	1,403	645.0	− 6.8	20	0.6	nnw	......	580
9.19 a. m.	720.1	5.4	54	nw.	8.5	991	679.7	− 3.2	62	2.3	nnw.	......	0
9.33 a. m.	720.1	5.6	53	nw.	10.7	526	720.1	5.6	53	3.7	nw.	10.7	......

May 9, 1913.—Seven kites were used; lifting surface, 46.6 sq. m. Wire out, 6,800 m.; at maximum altitude, 6,400 m.

Ci. and Ci.-St., from the west, varied from 3/10 to 5/10 till about 10 a. m. Thereafter there were 3/10 Ci. from the west and a few Cu. from the west-northwest. There was light haze. A solar halo was observed at 10.27 a. m.

High pressure (778 mm.), central over the Dakotas, extended southward to the middle Atlantic coast. Pressure was low (762 mm.) over Quebec.

May 10, 1913.—*First flight:* Four kites were used; lifting surface, 25.2 sq. m. Wire out, 4,600 m.; at maximum altitude, 4,400 m.

After 7 a. m. there were from 3/10 to 2/10 St.-Cu. from the north-northwest. A few Ci.-Cu., from the west-northwest, observed at 6.35 a. m., disappeared before 8 a. m. The head kite was in St.-Cu., altitude 1,100 m., at 7.10 and again at 9.19 a. m.

At 8 a. m. high pressure (777 mm.), central over Wisconsin, dominated conditions east of the Mississippi River.

Results of free-air observations—Continued.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Direction.	Velocity.				Rel.	Abs.	Dir.	Vel.	
May 10, 1913—Continued.													
Second flight—	*mm.*	*C.*	%		*m.p.s.*	*m.*	*mm.*	*C.*	%	*g/cu.m.*		*m.p.s.*	*Volts.*
10.02 a. m.	720.1	5.8	52	nw.	11.2	526	720.1	5.8	52	3.7	nw.	11.2	......
10.20 a. m.	720.0	6.1	42	nw.	11.2	895	687.9	− 1.7	55	2.3	nnw.	11.8	0
10.30 a. m.	719.9	6.2	40	nw.	14.3	1,459	640.3	− 7.3	54	1.4	nnw.	22.5	940
10.36 a. m.	719.9	6.6	38	nw.	12.5	1,696	621.4	− 2.9	35	1.3	nnw.	20.2	1,110
10.44 a. m.	719.8	7.1	38	nw.	12.1	1,936	602.8	− 3.1	26	1.0	nw.	20.4	1,270
10.59 a. m.	719.7	7.4	39	nw.	13.9	2,682	548.3	− 6.4	19	0.5	nw.	19.3	1,765
11.16 a. m.	719.6	7.3	36	nw.	13.4	3,471	494.8	−12.9	18	0.3	nw.	21.0	3,100
11.48 a. m.	719.5	7.9	34	nw.	15.2	2,725	544.6	− 6.8	16	0.4	nw.	20.2	1,595
11.54 a. m.	719.4	7.6	36	nw.	12.5	2,616	552.0	− 6.0	14	0.4	nnw.	20.4	1,505
11.59 a. m.	719.4	7.4	38	nw.	12.5	2,435	565.0	− 6.7	13	0.4	nnw.	19.6	1,360
12.05 p. m.	719.4	8.0	33	nw.	12.5	2,250	578.7	− 6.1	12	0.4	nnw.	21.0	1,240
12.10 p. m.	719.3	8.0	35	nw.	17.0	2,088	590.6	− 5.9	12	0.4	nnw.	19.5	1,060
12.11 p. m.	719.3	8.1	35	nw.	17.0	1,955	600.8	− 8.9	13	0.3	nnw.	19.5	915
12.14 p. m.	719.3	8.1	36	nw.	16.1	1,876	606.9	− 6.9	14	0.4	nnw.	18.7	830
12.15 p. m.	719.3	8.1	37	nw.	16.1	1,825	611.0	− 7.5	14	0.4	nnw.	18.7	765
12.18 p. m.	719.2	8.3	36	nw.	11.2	1,404	644.7	− 5.9	22	0.7	nnw.	13.9	240
12.35 p. m.	719.1	8.3	38	nw.	17.0	940	683.5	0.1	42	2.0	nnw.	12.2	10
12.46 p. m.	719.0	8.0	33	nw.	13.4	526	719.0	8.0	33	2.7	nw.	13.4	......
Third flight—													
1.25 p. m.	718.9	8.9	34	nw.	13.4	526	718.9	8.9	34	3.0	nw.	13.4	......
1.33 p. m.	718.8	9.1	31	nw.	12.1	1,013	677.2	0.5	38	1.9	nnw.	10.9	0
1.50 p. m.	718.8	9.3	32	nw.	13.4	1,352	649.1	− 3.3	44	1.6	nnw.	13.4	960
2.12 p. m.	718.8	9.5	31	nw.	7.6	1,562	632.1	− 6.4	52	1.5	nnw.	13.1	1,160
2.14 p. m.	718.8	9.7	30	nw.	10.3	1,897	605.2	− 9.1	54	1.3	nnw.	16.1	1,310
2.16 p. m.	718.7	9.9	29	nw.	12.5	2,111	589.0	− 6.1	46	1.4	nnw.	16.9	1,705
2.18 p. m.	718.7	10.1	28	nw.	13.0	2,378	569.3	− 5.1	40	1.3	nnw.	17.8	2,500
2.23 p. m.	718.7	9.2	33	nw.	17.0	2,815	538.1	− 7.2	34	0.9	nnw.	18.5	2,750
2.45 p. m.	718.6	9.7	29	nw.	8.9	3,726	477.6	−16.8	26	0.3	nnw.	22.7	4,600
3.16 p. m.	718.5	9.4	31	nw.	14.3	2,960	527.6	− 9.7	22	0.5	nw.	21.0	3,200
3.21 p. m.	718.5	9.4	31	nw.	10.7	2,784	539.8	− 8.5	22	0.5	nw.	19.6	2,700
3.25 p. m.	718.5	9.4	31	nw.	13.4	2,575	554.4	− 8.2	21	0.5	nw.	20.4	2,100
3.27 p. m.	718.5	9.4	31	nw.	12.1	2,450	563.6	− 9.1	20	0.5	nw.	20.4	1,735
3.29 p. m.	718.5	9.4	31	nw.	12.1	2,450	563.6	− 8.2	19	0.5	nw.	18.8	1,735
3.35 p. m.	718.4	9.8	30	nw.	12.5	2,161	585.1	−11.1	30	0.6	nw.	19.3	1,800
3.46 p. m.	718.4	10.0	29	nw.	10.3	1,455	640.6	− 4.3	44	1.5	nw.	13.9	460
3.58 p. m.	718.3	9.7	32	nw.	11.2	1,009	677.2	1.7	43	2.3	nw.	14.7	260
4.09 p. m.	718.3	9.9	35	nw.	11.2	526	718.3	9.9	35	3.2	nw.	11.2	......
Fourth flight—													
5.10 p. m.	718.1	9.2	29	nw.	12.5	526	718.1	9.2	29	2.6	nw.	12.5	......
5.22 p. m.	718.1	9.0	24	nw.	15.2	910	685.3	3.3	32	1.9	nw.	16.8	0
5.50 p. m.	718.2	8.4	31	nw.	12.1	1,353	648.5	− 3.1	44	1.7	nw.	15.1	1,040
6.05 p. m.	718.2	8.3	34	nw.	12.1	2,007	596.3	− 9.9	48	1.0	nw.	19.6	2,500
6.10 p. m.	718.2	8.0	34	nw.	12.1	2,248	578.3	− 8.5	44	1.1	nw.	22.7	3,530
6.14 p. m.	718.3	8.1	35	nw.	11.2	2,692	546.0	− 9.6	40	0.9	nw.	22.7	3,675
6.15 p. m.	718.3	8.1	35	nw.	11.2	2,791	538.9	− 9.1	40	0.9	nw.	22.7	3,700
6.21 p. m.	718.3	8.1	35	nw.	11.2	2,922	530.0	− 9.2	38	0.9	nw.	23.9	4,060
6.41 p. m.	718.4	7.4	37	nw.	13.9	3,574	486.4	−14.7	32	0.5	nw.	25.2	6,000
7.05 p. m.	718.5	6.8	37	nw.	12.1	3,239	507.8	−12.0	30	0.5	nw.	24.4	5,000
7.15 p. m.	718.5	6.5	38	nw.	10.7	3,001	524.0	−10.7	30	0.6	nw.	......	3,260
7.35 p. m.	718.6	6.0	39	nw.	11.2	2,448	562.8	−10.7	33	0.7	nw.	18.2	2,390
7.36 p. m.	718.6	6.0	39	nw.	11.2	2,397	566.5	−11.5	33	0.6	nw.	18.2	2,335
7.40 p. m.	718.6	5.9	40	nw.	9.4	2,241	578.3	−11.5	33	0.6	nw.	16.5	2,140
7.41 p. m.	718.6	5.9	40	nw.	9.4	2,186	582.3	−11.3	33	0.6	nw.	16.5	2,080
7.43 p. m.	718.6	5.8	40	nw.	12.1	2,081	590.2	−11.5	35	0.7	nw.	15.7	2,010
7.49 p. m.	718.6	5.7	38	nw.	9.8	1,951	600.4	−10.9	41	0.8	nw.	16.8	2,095
8.11 p. m.	718.7	5.4	37	nw.	8.9	1,352	648.5	− 4.5	48	1.6	nw.	16.8	1,430
8.26 p. m.	718.8	5.4	40	nw.	9.8	1,011	676.6	− 0.3	40	1.9	nw.	19.3	950
8.36 p. m.	718.9	5.0	41	nw.	9.8	526	718.9	5.0	41	2.8	nw.	9.8	......

Second flight: Four kites were used; lifting surface, 25.2 sq. m. Wire out, 5,000 m., at maximum altitude.

There were 2/10 St.-Cu. from the north-northwest before 11 a. m. Thereafter there were a few Cu. and St.-Cu. from the north-northwest.

Third flight: Five kites were used; lifting surface, 31.5 sq. m. Wire out, 5,600 m., at maximum altitude.

There were a few St.-Cu. from the north-northwest.

Fourth flight: Five kites were used; lifting surface, 31.5 sq. m. Wire out, 5,600 m., at maximum altitude.

There was light haze.

Results of free-air observations—Continued.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.								
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Direction.	Velocity.				Rel.	Abs.	Dir.	Vel.	
May 10 and 11, 1913:													
Fifth flight—	*mm.*	*C.*	%		*m.p.s.*	*m.*	*mm.*	*C.*	%	*g/cu.m.*		*m.p.s.*	*Volts.*
9.11 p. m..	719.2	4.4	44	nw.	9.8	526	719.2	4.4	44	2.9	nw.	9.8	......
9.29 p. m..	719.3	4.0	44	nw.	11.2	908	686.2	1.1	45	2.3	nw.	19.3	955
9.41 p. m..	719.4	4.0	43	nw.	9.8	1,326	651.5	− 4.2	49	1.7	nw.	20.2	1,685
9.51 p. m..	719.4	4.0	43	nw.	11.2	1,823	611.5	− 8.6	55	1.3	nw.	18.6	2,520
9.54 p. m..	719.5	4.0	43	nw.	10.7	1,980	599.2	− 8.0	54	1.4	nw.	16.8	2,710
9.55 p. m..	719.5	3.9	43	nw.	10.7	2,194	583.2	− 7.4	53	1.4	nw.	18.5	2,880
10.06 p. m..	719.5	3.8	44	nw.	9.8	2,299	575.2	− 8.2	48	1.2	nw.	19.4	2,980
10.11 p. m..	719.5	3.7	44	nw.	9.8	2,248	579.2	−11.6	48	0.9	nw.	17.8	2,940
10.13 p. m..	719.5	3.7	44	nw.	9.4	2,508	559.9	− 9.7	48	1.1	nw.	17.8	3,140
10.35 p. m..	719.6	3.4	44	nw.	11.6	3,175	513.7	−10.2	45	1.0	nw.	22.0	6,180
10.54 p. m..	719.6	3.3	45	nw.	12.1	3,910	465.9	−14.8	39	0.6	nw.	26.2	8,500
11.16 p. m..	719.7	3.1	48	nw.	11.6	3,588	485.5	−12.8	37	0.6	nw.	26.9	7,200
11.22 p. m..	719.7	3.0	47	nw.	9.8	3,511	490.5	−12.6	36	0.6	nw.	......	6,980
11.28 p. m..	719.7	2.8	46	nw.	10.3	3,356	500.4	−11.0	35	0.7	nw.	24.4	6,500
11.32 p. m..	719.7	2.7	46	nw.	9.8	3,254	507.1	−11.0	35	0.7	nw.	24.4	6,160
11.50 p. m..	719.8	2.6	44	nw.	8.9	3,053	520.6	− 9.8	35	0.8	nw.	......	5,600
11.53 p. m..	719.8	2.6	44	nw.	9.4	2,900	530.9	−10.2	36	0.8	nw.	......	5,180
11.57 p. m..	719.8	2.6	44	nw.	8.5	2,646	548.8	− 9.8	37	0.8	nw.	......	4,480
May 11, 1913:													
12.08 a. m..	719.8	2.2	47	nw.	8.0	2,281	575.2	− 9.8	42	0.9	nw.	17.2	3,740
12.14 a. m..	719.8	2.3	45	nw.	6.7	1,913	603.3	−11.8	51	1.0	nw.	16.3	2,800
12.27 a. m..	719.8	2.4	43	nw.	8.0	1,449	640.8	− 7.8	65	1.7	nw.	15.1	1,685
12.41 a. m..	719.9	2.1	45	nw.	8.5	1,011	677.5	− 2.7	63	2.5	nw.	17.6	1,050
12.49 a. m..	719.9	2.2	46	nw.	8.9	526	719.9	2.2	46	2.6	nw.	8.9	......
Sixth flight—													
1.19 a. m...	719.9	1.2	51	nw.	7.2	526	719.9	1.2	51	2.7	nw.	7.2	......
1.33 a. m...	719.9	1.1	49	nw.	7.2	930	684.5	− 1.2	46	2.0	wnw.	13.0	755
1.46 a. m...	719.9	1.0	50	nw.	6.3	1,431	642.4	− 7.2	57	1.5	nw.	17.6	1,640
1.56 a. m...	719.9	1.0	50	nw.	5.8	1,912	603.8	−12.3	73	1.3	nnw.	16.5	3,380
1.57 a. m...	719.9	1.0	50	nw.	5.8	1,965	599.7	−10.6	69	1.4	nnw.	16.5	3,540
1.58 a. m...	719.9	1.0	50	nw.	5.8	1,989	597.7	−11.0	68	1.3	nnw.	16.5	3,680
2.00 a. m...	719.9	1.0	50	nw.	6.3	2,071	591.6	− 8.4	59	1.4	nnw.	16.4	3,720
2.12 a. m...	719.9	1.1	50	nw.	7.2	2,282	575.7	− 9.0	48	1.1	nw.	21.7	4,210
2.15 a. m...	719.9	1.0	50	nw.	7.6	2,438	564.2	− 8.3	44	1.1	nw.	21.7	5,150
2.50 a. m...	719.8	1.3	48	nw.	8.9	8,558	487.8	−13.2	27	0.4	nw.	24.4	8,700
3.22 a. m...	719.8	1.0	50	nw.	9.4	2,875	533.1	− 9.2	27	0.6	nw.	24.4	5,700
3.35 a. m...	719.9	1.0	53	nw.	9.8	2,590	553.0	− 8.2	28	0.7	nw.	24.2	4,840
3.44 a. m...	719.9	1.1	54	nw.	10.3	2,224	579.7	− 8.0	28	0.7	nw.	20.8	3,760
3.57 a. m...	719.9	0.9	58	nw.	9.4	2,040	593.6	− 7.0	30	0.8	nw.	20.6	3,020
3.59 a. m...	719.9	0.9	58	nw.	9.4	1,932	601.8	− 7.2	30	0.8	nnw.	15.6	2,710
4.01 a. m...	719.9	0.8	59	nw.	8.9	1,802	612.0	−11.0	48	0.9	nnw.	15.6	2,320
4.09 a. m...	719.9	0.7	60	nw.	8.5	1,477	638.2	− 9.0	66	1.5	nnw.	13.4	1,520
4.26 a. m...	719.9	0.8	59	nw.	9.8	916	685.6	− 2.8	62	2.4	wnw.	16.8	490
4.33 a. m...	720.0	0.5	61	nw.	8.5	526	720.0	0.5	61	3.1	nw.	8.5	....

May 10 and 11, 1913.—Fifth flight: Five kites were used; lifting surface, 30.5 sq. m. Wire out, 5,600 m.; at maximum altitude, 5,400 m.

The sky was cloudless before 12.30 a. m. Thereafter there were a few St.-Cu. from the northwest.

May 11, 1913.—Sixth flight: Five kites were used; lifting surface, 32.0 sq. m. Wire out, 5,500 m., at maximum altitude.

There were few to 4/10 St.-Cu. from the northwest.

Results of free-air observations—Continued.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Direction.	Velocity.				Rel.	Abs.	Dir.	Vel.	
May 11, 1913—Continued.													
Seventh flight—	*mm.*	*C.*	%		*m.p.s.*	*m.*	*mm.*	*C.*	%	*g/cu.m.*		*m.p.s.*	*Volts.*
5.12 a. m.	720.1	0.1	62	nw.	8.9	526	720.1	0.1	62	3.0	nw.	8.9	......
5.23 a. m.	720.1	0.0	64	nw.	8.9	929	684.5	− 3.6	62	2.3	nnw.	13.9	1,010
5.37 a. m.	720.2	0.0	64	nw.	8.0	1,518	634.9	− 9.6	63	1.4	nnw.	15.1	2,150
5.41 a. m.	720.2	0.0	63	nw.	7.2	1,679	620.3	−10.2	65	1.4	nnw.	20.2	2,460
5.46 a. m.	720.2	0.0	62	nw.	7.6	2,222	579.7	− 9.0	50	1.2	nnw.	25.2	3,820
6.10 a. m.	720.3	0.2	60	nw.	7.2	3,123	516.0	− 9.5	34	0.8	nnw.	21.8	6,000
6.35 a. m.	720.4	0.7	63	nw.	8.5	3,771	474.6	−14.6	29	0.4	nnw.	24.4	8,020
7.10 a. m.	720.5	1.6	60	nw.	8.9	3,115	517.6	− 9.6	28	0.6	nnw.	23.5	5,200
7.19 a. m.	720.5	1.7	59	nw.	10.3	2,934	529.7	− 8.6	28	0.7	nnw.	20.0	4,810
7.28 a. m.	720.5	1.9	56	nw.	9.4	2,548	556.7	− 8.2	29	0.7	nnw.	20.0	3,900
7.34 a. m.	720.4	2.0	54	nw.	10.7	2,312	573.7	− 6.2	27	0.8	nnw.	18.3	3,350
7.40 a. m.	720.4	2.2	57	nw.	9.4	2,259	577.7	− 6.5	23	0.7	nnw.	21.0	2,800
7.42 a. m.	720.4	2.3	58	nw.	9.8	2,205	581.7	− 6.4	22	0.5	nnw.	23.6	2,660
7.51 a. m.	720.4	2.7	57	nw.	9.8	1,940	601.8	− 7.6	29	0.8	nnw.	24.4	2,200
7.59 a. m.	720.4	3.2	56	nw.	9.8	1,670	622.4	−10.6	48	1.0	nnw.	23.6	1,720
8.21 a. m.	720.3	3.6	50	nw.	11.6	985	680.2	− 3.6	66	2.4	nnw.	......	0
8.39 a. m.	720.1	5.0	51	nw.	11.6	526	720.1	5.0	51	3.4	nw.	11.6	......
Eighth flight—													
9.44 a. m.	719.6	5.4	44	nw.	11.6	526	719.6	5.4	44	3.1	nw.	11.6	......
9.54 a. m.	719.6	5.6	47	nw.	11.2	787	696.8	− 1.0	50	2.2	nnw.	14.7	0
10.08 a. m.	719.5	5.6	47	nw.	10.7	1,041	674.8	− 4.1	58	2.0	nw.	13.0	640
10.30 a. m.	719.4	6.3	45	nw.	12.5	1,791	613.1	− 8.5	47	1.1	nnw.	19.1	1,470
10.32 a. m.	719.4	6.3	45	nw.	12.1	1,949	600.8	− 8.1	45	1.1	nnw.	22.1	1,680
10.33 a. m.	719.4	6.4	45	nw.	12.1	2,056	592.6	− 8.7	43	1.0	nnw.	20.4	1,840
10.43 a. m.	719.4	6.7	42	nw.	12.5	2,582	553.7	− 9.0	39	0.9	nnw.	21.2	2,540
10.51 a. m.	719.3	7.0	40	nw.	13.9	3,241	508.2	−13.7	38	0.6	nnw.	19.3	3,420
10.59 a. m.	719.3	7.0	43	nw.	13.4	3,367	499.9	−13.7	37	0.6	nnw.	24.4	3,660
11.01 a. m.	719.3	7.0	43	nw.	13.4	3,406	497.4	−14.1	37	0.6	nnw.	23.7	3,750
11.06 a. m.	719.3	7.0	43	nw.	11.6	3,370	499.9	−13.9	37	0.6	nnw.	22.8	3,740
11.16 a. m.	719.2	7.0	43	nw.	11.6	3,267	506.6	−13.9	36	0.6	nnw.	22.8	3,680
11.21 a. m.	719.2	7.0	43	nw.	10.7	3,067	520.1	−12.9	36	0.6	nnw.	22.8	3,590
11.25 a. m.	719.1	7.0	43	nw.	9.8	3,014	523.5	−13.3	36	0.6	nnw.	24.5	3,560
11.33 a. m.	719.1	7.6	39	nw.	8.9	2,991	525.2	−12.9	36	0.6	nnw.	24.4	3,540
11.35 a. m.	719.0	7.8	38	nw.	10.7	2,324	572.7	− 9.1	36	0.8	nnw.	21.0	1,840
11.57 a. m.	718.9	8.0	36	nw.	12.1	2,084	590.6	− 7.8	33	0.9	nnw.	16.8	1,520
12.00 m.	718.9	8.1	36	nw.	10.7	1,926	602.8	− 9.7	35	0.8	nnw.	16.0	1,300
12.05 p. m.	718.9	8.5	37	nw.	12.5	1,809	612.0	− 6.9	37	1.0	nw.	15.0	1,220
12.09 p. m.	718.8	8.8	36	nw.	10.3	1,772	615.1	− 8.9	45	1.1	nw.	15.4	1,170
12.23 p. m.	718.7	8.4	34	nw.	11.6	1,324	651.0	− 4.1	55	1.9	nw.	12.6	640
12.40 p. m.	718.6	9.3	36	nw.	10.3	884	687.9	1.9	47	2.6	nw.	12.6	0
12.49 p. m.	718.5	9.8	38	nw.	8.0	526	718.5	9.8	38	3.5	nw.	8.0	......

Seventh flight: Four kites were used; lifting surface, 25.2 sq. m. Wire out, 5,500 m., at maximum altitude.

The sky was cloudless until 8 a. m. Thereafter there were a few St.-Cu. from the north-northwest.

At 8 a. m., high pressure (772 mm.), central over Michigan, covered the eastern half of the United States.

Eighth flight: Four kites were used; lifting surface, 25.2 sq. m. Wire out, 4,500 m., at maximum altitude.

There were a few St.-Cu. from the north-northwest.

Results of free-air observations—Continued.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Direction.	Velocity.				Rel.	Abs.	Dir.	Vel.	
May 11, 1913—Continued.													
Ninth flight—	*mm.*	*C.*	%		*m.p.s.*	*m.*	*mm.*	*C.*	%	*g/cu.m.*		*m.p.s.*	*Volts.*
1.36 p. m.	718.1	9.4	39	nw.	8.5	526	718.1	9.4	39	3.5	nw.	8.5	......
2.01 p. m.	717.9	10.4	31	nw.	9.8	861	689.3	3.6	33	2.0	nnw.	13.4	......
2.28 p. m.	717.7	9.7	30	nw.	8.9	1,378	646.0	− 2.0	38	1.6	nnw.	12.4	810
3.04 p. m.	717.4	10.9	26	nw.	10.7	2,061	592.2	−10.0	50	1.1	nnw.	14.7	1,550
3.14 p. m.	717.3	11.3	26	nw.	10.7	2,319	572.5	−12.6	53	0.9	nnw.	18.6	1,950
3.15 p. m.	717.3	11.4	26	nw.	10.7	2,565	554.6	−10.4	53	1.1	nnw.	20.3	2,320
3.24 p. m.	717.2	11.8	25	nw.	7.6	3,166	512.7	−14.2	42	0.6	nnw.	19.4	3,360
3.34 p. m.	717.1	11.0	25	nw.	11.2	3,502	490.4	−16.4	36	0.4	nnw.	27.7	4,500
3.59 p. m.	716.9	11.3	24	nnw.	10.7	3,183	511.8	−15.0	36	0.5	n.	20.2	3,700
4.14 p. m.	716.9	11.6	28	nnw.	10.3	2,659	548.2	−11.4	35	0.7	n.	22.3	2,440
4.16 p. m.	716.9	11.6	28	nnw.	9.4	2,584	553.6	−12.0	35	0.6	n.	18.1	2,300
4.23 p. m.	716.9	11.4	28	nnw.	11.2	2,533	557.3	− 9.8	35	0.8	n.	19.3	2,300
4.27 p. m.	716.9	11.3	29	nnw.	9.4	2,354	570.5	−10.6	35	0.7	n.	17.1	2,030
4.40 p. m.	716.8	11.4	28	nnw.	8.9	1,800	612.5	− 5.9	47	1.4	nnw.	17.6	1,315
4.55 p. m.	716.8	11.3	28	nnw.	9.4	1,246	656.7	1.0	43	2.2	nnw.	13.9	680
5.06 p. m.	716.8	11.1	26	nnw.	11.2	877	687.1	5.8	36	2.6	nnw.	15.2	170
5.11 p. m.	716.8	11.0	26	nnw.	10.3	526	716.8	11.0	26	2.6	nnw.	10.3	......
Tenth flight—													
5.49 p. m.	716.7	10.5	30	nnw.	8.9	526	716.7	10.5	30	2.9	nnw.	8.9	......
6.00 p. m.	716.7	10.4	31	nnw.	8.0	935	682.2	5.5	31	2.2	nnw.	13.4	170
6.20 p. m.	716.7	10.0	33	nw.	6.3	1,355	647.6	− 0.4	37	1.7	nnw.	12.6	810
6.38 p. m.	716.6	9.6	34	nw.	5.4	1,827	610.0	− 6.4	49	1.4	nw.	15.8	1,430
6.57 p. m.	716.6	8.9	37	nw.	4.9	2,399	566.4	−11.9	58	1.1	nw.	21.0	2,040
7.05 p. m.	716.6	8.9	37	nw.	6.3	2,603	551.6	−11.0	50	1.0	nw.	19.2	2,720
7.28 p. m.	716.6	9.2	32	nw.	7.2	3,595	483.6	−17.9	38	0.4	nnw.	26.9	5,500
8.02 p. m.	716.7	8.4	37	nw.	8.0	2,912	528.7	−12.4	35	0.6	nnw.	19.2	3,480
8.06 p. m.	716.7	8.5	36	nw.	8.0	2,887	530.4	−13.2	34	0.6	nnw.	20.2	3,470
8.14 p. m.	716.8	8.5	35	nw.	7.2	2,666	546.2	−12.4	35	0.6	nnw.	19.7	[illegible]
8.16 p. m.	716.8	8.4	36	nw.	7.2	2,411	564.6	−14.2	36	0.5	nnw.	15.5	[illegible]
8.29 p. m.	716.9	8.3	38	nw.	6.3	1,869	606.0	− 7.8	51	1.3	nnw.	16.0	1,480
8.46 p. m.	717.0	8.4	34	nw.	7.2	1,327	649.9	− 0.6	48	2.2	nnw.	16.8	1,040
8.59 p. m.	717.1	8.1	38	nw.	6.7	910	684.4	4.4	40	2.6	nnw.	14.7	425
9.06 p. m.	717.2	8.3	32	nw.	7.2	526	717.2	8.3	32	2.7	nw.	7.2	......
Eleventh flight—													
9.27 p. m.	717.4	8.4	36	nw.	7.6	526	717.4	8.4	36	3.0	nw.	7.6	......
9.48 p. m.	717.7	7.5	37	nnw.	6.3	974	679.7	4.8	34	2.3	nnw.	12.6	810
10.16 p. m.	717.9	6.7	43	nnw.	4.9	1,381	646.2	− 0.7	38	1.7	nnw.	9.2	1,470
10.31 p. m.	718.0	6.6	42	nnw.	4.5	1,743	617.6	− 4.8	44	1.5	n.	7.5	1,470
11.16 p. m.	718.3	6.2	42	ne.	3.1	1,957	601.0	− 8.3	55	1.4	n.	8.4	[illegible]
11.36 p. m.	718.4	5.7	40	ne.	3.1	2,050	592.9	− 9.7	57	1.3	n.	......	......
11.45 p. m.	718.5	5.8	37	ene.	2.7	1,342	649.3	− 3.1	56	2.1	nne.	9.8	860
11.59 p. m.	718.6	5.2	37	ene.	2.7	526	718.6	5.2	37	2.5	ene.	2.7	......

Ninth flight: Five kites were used; lifting surface, 32.5 sq. m. Wire out, 5,500 m., at maximum altitude.

There were a few St.-Cu. from the northwest before 3 p. m. Thereafter the sky was cloudless.

Tenth flight. Five kites were used; lifting surface, 32.0 sq. m. Wire out, 5,500 m., at maximum altitude.

There was light haze.

Eleventh flight. Four kites were used; lifting surface, 26.2 sq. m. Wire out, 3,200 m.; at maximum altitude, 1,700 m.

There was light haze.

Results of free-air observations—Continued.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Direction.	Velocity.				Rel.	Abs.	Dir.	Vel.	
May 19, 1913:	*mm.*	*C.*	*%*		*m.p.s*	*m.*	*mm.*	*C.*	*%*	*g/cu.m.*		*m.p.s.*	*Volts.*
10.09 a. m.	718.1	13.9	52	nw.	10.8	526	718.1	13.9	52	6.2	nw.	10.8	......
10.22 a. m.	718.1	15.0	48	nw.	7.6	817	693.7	8.5	55	4.7	nw.	10.7	0
10.38 a. m.	718.1	14.4	47	wnw.	8.5	1,041	675.0	7.1	55	4.3	nw.	8.7	0
11.01 a. m.	718.1	15.3	46	wnw.	8.5	1,523	636.3	0.9	48	2.5	wnw.	13.1	380
11.02 a. m.	718.1	15.4	46	wnw.	7.6	1,537	635.2	1.5	48	2.6	wnw.	13.1	390
11.04 a. m.	718.1	15.4	47	wnw.	7.6	1,620	628.8	1.6	46	2.5	wnw.	13.1	420
11.06 a. m.	718.1	15.5	47	wnw.	8.0	1,974	601.9	3.3	35	2.1	wnw.	18.1	760
11.28 a. m.	718.1	16.0	46	wnw.	8.9	2,580	558.5	1.1	70	3.6	wnw.	26.7	1,020
11.30 a. m.	718.0	16.0	46	wnw.	10.7	2,687	551.1	1.6	67	3.6	wnw.	......	1,200
11.40 a. m.	718.0	16.0	46	wnw.	8.0	2,737	547.4	0.8	69	3.5	wnw.	......	......
12.11 p. m.	718.0	16.1	45	wnw.	7.2	2,390	571.8	− 0.3	74	3.5	nw.	......	970
12.25 p. m.	717.9	16.6	46	wnw.	8.5	2,060	595.8	0.9	46	2.4	wnw.	18.6	660
12.28 p. m.	717.9	16.7	47	wnw.	7.2	1,896	608.0	0.0	49	2.4	wnw.	17.4	600
12.50 p. m.	717.8	16.6	42	nw.	8.9	1,178	664.1	6.4	57	4.2	nw.	9.9	170
1.04 p. m.	717.8	17.8	42	nw.	7.2	777	697.0	12.3	50	5.4	nw.	8.3	0
1.09 p. m.	717.7	17.4	48	nw.	6.3	526	717.7	17.4	48	7.0	nw.	6.3	......
June 12, 1913:													
First flight—													
8.21 a. m.	717.7	14.7	87	nw.	6.3	526	717.7	14.7	87	10.9	nw.	6.3	......
8.36 a. m.	717.7	15.2	84	nw.	5.8	928	684.4	12.1	53	5.6	nnw.	12.2	0
8.51 a. m.	717.7	16.1	83	nw.	6.3	1,408	646.5	11.8	27	2.8	n.	11.0	580
8.53 a. m.	717.7	16.1	84	nw.	6.3	1,436	644.3	12.6	26	2.9	n.	9.8	600
9.02 a. m.	717.7	16.7	80	nw.	6.3	2,186	589.2	8.8	21	1.8	n.	15.5	840
9.18 a. m.	717.6	17.2	74	nw.	7.2	2,621	558.8	3.7	24	1.5	nne.	14.7	1,010
9.40 a. m.	717.4	17.9	69	nw.	8.9	3,421	505.8	− 1.8	18	0.8	nne.	19.7	1,500
9.44 a. m.	717.3	17.9	66	nw.	9.4	3,462	503.3	− 1.1	16	0.7	nne.	19.7	1,540
9.51 a. m.	717.3	18.2	64	nw.	9.8	3,767	484.4	− 4.2	15	0.5	nne.	19.7	1,710
10.30 a. m.	717.0	19.6	69	nw.	8.0	3,971	472.0	− 6.4	11	0.3	nne.	16.8	1,930
11.02 a. m.	716.9	20.0	61	nw.	7.6	4,354	449.4	−11.3	10	0.2	nne.	18.5	2,160
11.30 a. m.	716.6	20.4	62	nw.	8.5	4,588	435.0	−14.4	11	0.2	nne.	19.6	......
12.05 p. m.	716.4	21.4	57	nw.	9.4	4,248	454.6	−11.4	11	0.2	nne.	18.2	1,600
12.26 p. m.	716.2	21.8	53	nw.	9.4	3,842	478.6	− 8.1	11	0.3	nne.	17.2	1,315
12.51 p. m.	716.0	22.0	47	nw.	8.9	3,373	508.4	− 2.1	11	0.5	nne.	18.6	860
1.12 p. m.	715.9	22.0	46	nw.	8.0	2,513	565.5	3.9	8	0.5	nne.	......	425
1.30 p. m.	715.8	22.4	46	nw.	9.8	1,838	613.7	10.9	11	1.1	n.	......	260
1.42 p. m.	715.8	22.7	46	nw.	8.5	1,344	650.7	15.8	11	1.5	n.	......	0
1.46 p. m.	715.7	22.7	46	nw.	9.4	1,343	650.7	14.5	10	1.2	n.	......	0
1.47 p. m.	715.7	22.7	46	nw.	9.4	1,343	650.7	15.2	11	1.4	n.	......	0
1.49 p. m.	715.7	22.8	46	nw.	8.5	1,286	655.1	13.7	11	1.3	n.	......	0
2.00 p. m.	715.7	23.0	46	nw.	8.5	886	686.6	17.0	28	4.0	nnw.	......	0
2.10 p. m.	715.7	23.0	45	nw.	8.5	526	715.7	23.0	45	9.2	nw.	8.5	......

May 19, 1913.—Five kites were used; lifting surface, 34.5 sq. m. Wire out, 4,500 m., at maximum altitude.

There was 1/10 St.-Cu. from the west-northwest, till about 10.45 a. m., when there were 2/10 Ci. from the west and 1/10 St.-Cu. from the west-northwest. After 12.30 p. m. there were 6/10 Ci. from the west and a few Cu. from the west-northwest.

High pressure (770 mm.), central over Manitoba, extended to Tennessee. Low pressure (753 mm.), central over New Brunswick, skirted the Atlantic seaboard.

June 12, 1913.—*First flight:* Eight kites were used; lifting surface, 53.4 sq. m. Wire out, 10,000 m.; at maximum altitude, 9,200 m.

Ci.-St., from west, increased from 3/10 to 6/10.

At 8 a. m., high pressure (770 mm.) was central over southern Indiana. Low pressure (731 mm.) was central off the North Carolina coast.

Results of free-air observations—Continued.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P.D. kite and earth.
				Direction.	Velocity.				Rel.	Abs.	Dir.	Vel.	
May 12, 1913—Continued.													
Second flight—	*mm.*	*C.*	%		*m.p.s.*	*m.*	*mm.*	*C.*	%	*g/cu.m.*		*m.p.s.*	*Volts.*
2.42 p.m..	715.6	23.4	41	nnw.	10.3	526	715.6	23.4	41	8.5	nnw.	10.3	......
2.50 p.m..	715.5	23.3	40	nnw.	10.3	917	684.1	18.1	35	5.4	nnw.	11.8	0
3.19 p.m..	715.4	23.0	37	nnw.	6.3	1,600	631.2	13.0	28	3.1	n.	8.0	340
3.36 p.m..	715.3	23.6	41	nnw.	6.3	2,077	596.1	8.8	18	1.6	nne.	10.1	565
4.03 p.m..	715.2	23.5	42	nnw.	7.6	2,461	569.1	2.6	22	1.3	nne.	10.9	760
4.18 p.m..	715.1	23.4	42	nnw.	4.9	2,523	564.4	2.9	23	1.4	nne.	10.9	780
4.21 p.m..	715.1	23.5	42	nnw.	4.9	2,618	557.8	3.3	22	1.3	nne.	10.1	800
4.23 p.m..	715.1	23.5	42	nnw.	4.9	2,717	551.2	2.5	21	1.2	nne.	10.5	818
4.30 p.m..	715.1	23.6	42	nnw.	5.8	2,729	550.4	2.3	18	1.0	nne.	......	810
4.40 p.m..	715.1	23.4	43	nnw.	6.3	3,020	530.5	− 0.7	14	0.6	nne.	10.4	......
4.54 p.m..	715.0	23.5	42	nnw.	5.8	2,597	558.7	3.2	12	0.7	nne.	12.0	425
4.58 p.m..	715.0	23.4	40	nnw.	5.8	2,378	574.1	2.7	14	0.8	nne.	8.8	420
5.02 p.m..	715.0	23.3	39	nnw.	5.8	2,323	578.1	3.6	17	1.0	nne.	10.1	420
5.16 p.m..	715.1	23.2	35	nnw.	8.5	1,677	625.0	11.6	20	2.1	nne.	12.2	260
5.31 p.m..	715.2	23.4	38	nnw.	8.0	1,344	650.4	13.6	27	3.2	nne.	12.6	0
5.45 p.m..	715.3	23.0	40	nnw.	6.3	914	684.1	18.4	34	5.3	n.	12.1	0
5.53 p.m..	715.4	22.6	42	nnw.	6.7	526	715.4	22.6	42	8.4	nnw.	6.7	......
Third flight—													
6.18 p.m..	715.4	22.7	39	nnw.	6.3	526	715.4	22.7	39	7.8	nnw.	6.3	......
6.31 p.m..	715.5	22.4	49	nnw.	5.8	904	685.2	19.9	37	6.3	n.	13.6	0
7.03 p.m..	715.5	21.8	36	nnw.	5.8	1,336	651.5	16.2	31	4.2	n.	18.4	0
7.17 p.m..	715.6	21.3	49	nnw.	5.4	1,802	616.6	11.1	27	2.7	n.	10.7	330
7.36 p.m..	715.7	21.0	38	nnw.	4.5	2,269	583.1	5.7	27	1.9	nne.	10.5	540
7.59 p.m..	715.9	21.6	34	nne.	5.4	2,601	559.6	0.8	29	1.5	nne.	9.6	755
8.29 p.m..	716.0	21.7	31	ne.	5.4	2,965	535.0	− 3.0	36	1.4	nne.	12.6	690
8.33 p.m..	716.0	21.7	31	ne.	4.9	3,104	525.5	− 2.8	35	1.4	ne.	18.4	......
8.35 p.m..	716.0	21.7	31	ne.	4.9	3,130	523.6	− 3.0	36	1.4	ne.	13.8	......
8.38 p.m..	716.0	21.7	31	ne.	4.9	3,023	530.5	− 3.2	37	1.4	ne.	10.9	[illegible]
8.43 p.m..	716.0	21.5	33	ne.	4.5	2,851	542.2	− 2.2	37	1.5	ne.	13.7	705
8.57 p.m..	716.1	21.8	29	ne.	4.9	2,212	587.0	3.8	37	2.3	ne.	7.8	380
9.12 p.m..	716.1	21.7	31	ne.	4.5	1,806	616.6	9.9	32	3.0	ne.	8.4	170
9.28 p.m..	716.1	21.2	32	ne.	7.2	1,439	644.1	14.8	31	3.9	nne.	11.4	0
9.41 p.m..	716.0	21.5	30	nne.	6.7	963	680.8	19.3	27	4.4	nne.	10.1	0
9.47 p.m..	716.0	21.0	38	nne.	6.3	526	716.0	21.0	38	6.9	nne.	6.3	......
June 14, 1913:													
8.52 a.m..	715.5	21.6	51	wnw.	9.8	526	715.5	21.6	51	9.6	wnw.	9.8	......
9.04 a.m..	715.5	21.6	53	wnw.	9.4	944	681.9	19.1	47	7.6	nw.	16.1	0
9.16 a.m..	715.5	22.2	53	wnw.	8.5	1,335	651.5	16.2	51	7.0	nw.	13.4	170
10.24 a.m..	715.4	24.2	48	wnw.	8.0	1,859	612.3	11.7	53	5.5	nnw.	7.1	380
10.36 a.m..	715.3	24.8	45	wnw.	8.0	2,958	535.5	2.0	53	2.9	nnw.	13.6	380
10.50 a.m..	715.2	25.0	48	wnw.	7.2	2,235	584.8	5.2	57	3.9	nnw.	12.6	0
11.00 a.m..	715.2	25.1	45	wnw.	7.6	1,842	613.3	9.2	70	6.2	nw.	12.1	0
11.13 a.m..	715.1	25.7	44	wnw.	7.6	1,288	654.8	14.8	62	7.8	nw.	10.9	0
11.26 a.m..	715.0	25.5	42	wnw.	7.2	801	693.0	21.2	50	9.2	nw.	10.5	0
11.33 a.m..	714.9	25.8	42	wnw.	7.6	526	714.9	25.8	42	10.0	wnw.	7.6	......

Second flight: Six kites were used; lifting surface, 42.3 sq.m. Wire out, 5,000 m.; at maximum altitude, 3,900 m.

There were 9/10 Ci.-St. from the west till about 4.30 p. m.; thereafter, 5/10 Ci.-St. and 5/10 St.-Cu. from the north-northwest. The second Ci.-St. were at a much lower level.

Third flight: Six kites were used; lifting surface, 41.3 sq. m. Wire out, 5,100 m.; at maximum altitude, 4,500 m.

Cloudiness varied from 5/10 Ci.-St. and 5/10 St.-Cu., from the north-northeast, to 4/10 Ci.-St. from the north-northeast, at about 8.20 p. m., and to 2/10 Ci.-St., from the north-northeast, at about 9.20 p. m.

June 14, 1913.—Five kites were used; lifting surface, 35.5 sq. m. Wire out, 4,500 m.; at maximum altitude, 3,400 m.

There was light haze.

High pressure (766 mm.) was central over Tennessee. Low pressure (752 mm.) was central over Newfoundland.

Results of free-air observations—Continued.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Direction.	Velocity.				Rel.	Abs.	Dir.	Vel.	
June 20, 1913:													
First flight—	*mm.*	*C.*	*%*		*m.p.s*	*m.*	*mm.*	*C.*	*%*	*g/cu.m.*		*m.p.s.*	*Volts.*
8.37 a.m.	717.2	21.4	72	wnw.	11.6	526	717.2	21.4	72	13.4	wnw.	11.6	......
8.41 a.m.	717.2	21.4	72	wnw.	11.6	799	695.0	19.6	72	12.0	nnw.	14.8	0
8.49 a.m.	717.2	21.2	73	wnw.	14.3	867	689.5	20.1	64	11.0	wnw.	......	0
8.54 a.m.	717.2	21.2	74	wnw.	12.5	1,091	671.9	22.5	50	9.9	wnw.	......	170
8.59 a.m.	717.2	21.1	76	wnw.	11.6	1,362	651.3	20.5	47	8.3	wnw.	......	380
9.02 a.m.	717.2	21.2	77	wnw.	11.6	1,377	650.2	20.8	47	8.4	w.	......	250
9.06 a.m.	717.2	21.3	78	wnw.	10.7	1,392	649.1	19.8	48	8.1	w.	......	0
9.18 a.m.	717.1	21.8	73	wnw.	11.6	1,923	610.2	16.4	44	6.1	w.	14.8	330
9.35 a.m.	717.1	22.2	70	wnw.	11.6	2,837	547.1	5.6	62	4.4	w.	18.5	......
9.45 a.m.	717.1	22.3	70	wnw.	11.2	1,924	610.2	15.6	53	7.0	w.	18.7	110
10.08 a.m.	717.0	22.2	73	wnw.	7.2	1,378	650.2	20.6	48	8.5	wnw.	16.8	0
10.21 a.m.	717.0	22.4	71	w.	6.3	1,022	677.4	22.8	48	9.7	w.	15.1	0
10.25 a.m.	717.0	22.7	70	w.	6.7	1,008	678.5	23.5	47	9.8	w.	14.3	0
10.32 a.m.	717.1	23.4	70	w.	5.8	704	702.7	21.2	58	10.6	w.	11.6	0
10.36 a.m.	717.1	23.8	70	w.	5.4	526	717.1	23.8	70	14.9	w.	5.4	......
Second flight—													
11.09 a.m.	717.0	24.6	66	w.	5.4	526	717.0	24.6	66	14.7	w.	5.4	......
11.22 a.m.	716.9	25.8	60	sw.	6.7	759	698.2	23.4	60	12.5	w.	8.4	0
11.27 a.m.	716.8	26.2	57	sw.	6.7	800	694.9	24.0	53	11.4	w.	8.4	0
11.32 a.m.	716.8	26.6	55	wsw.	4.5	1,012	678.4	24.8	47	10.6	w.	10.9	0
11.35 a.m.	716.7	26.6	55	wsw.	5.4	1,039	676.2	24.1	45	9.7	w.	12.2	0
11.49 a.m.	716.6	26.6	55	wsw.	5.8	1,210	663.2	24.4	43	9.5	w.	13.0	0
11.59 a.m.	716.5	26.8	54	wsw.	6.3	1,556	637.4	21.1	50	9.1	w.	14.0	0
12.16 p.m.	716.4	28.0	52	wsw.	5.4	1,928	610.2	16.9	51	7.3	wnw.	14.3	170
12.59 p.m.	716.0	28.6	52	wsw.	4.9	2,243	587.8	14.2	52	6.3	wnw.	12.9	0
1.10 p.m.	715.9	28.6	50	wsw.	4.5	1,806	618.5	17.2	55	8.0	w.	13.0	0
1.23 p.m.	715.8	28.8	50	wsw.	4.0	919	684.9	24.2	62	13.5	w.	......	0
1.28 p.m.	715.8	28.8	50	w.	4.0	526	715.8	28.8	50	14.1	w.	4.0	......

June 20, 1913.—First flight: Four kites were used; lifting surface, 25.2 sq. m. Wire out, 3,500 m. at maximum altitude.

The sky was covered with St.-Cu. from the west-northwest. Light rain began at 8.51 a. m. and ended at 9.32 a. m.

At 8 a. m. pressure was high (767 mm.) over Georgia. Low pressure (758 mm.) was central over Wisconsin.

June 20, 1913.—Second flight: Four kites were used; lifting surface, 25.2 sq. m. Wire out, 3,000 m.; at maximum altitude, 2,600 m.

There were 3/10 A.-St. and a few St.-Cu. from the west before noon; thereafter there were a few St.-Cu. from the west.

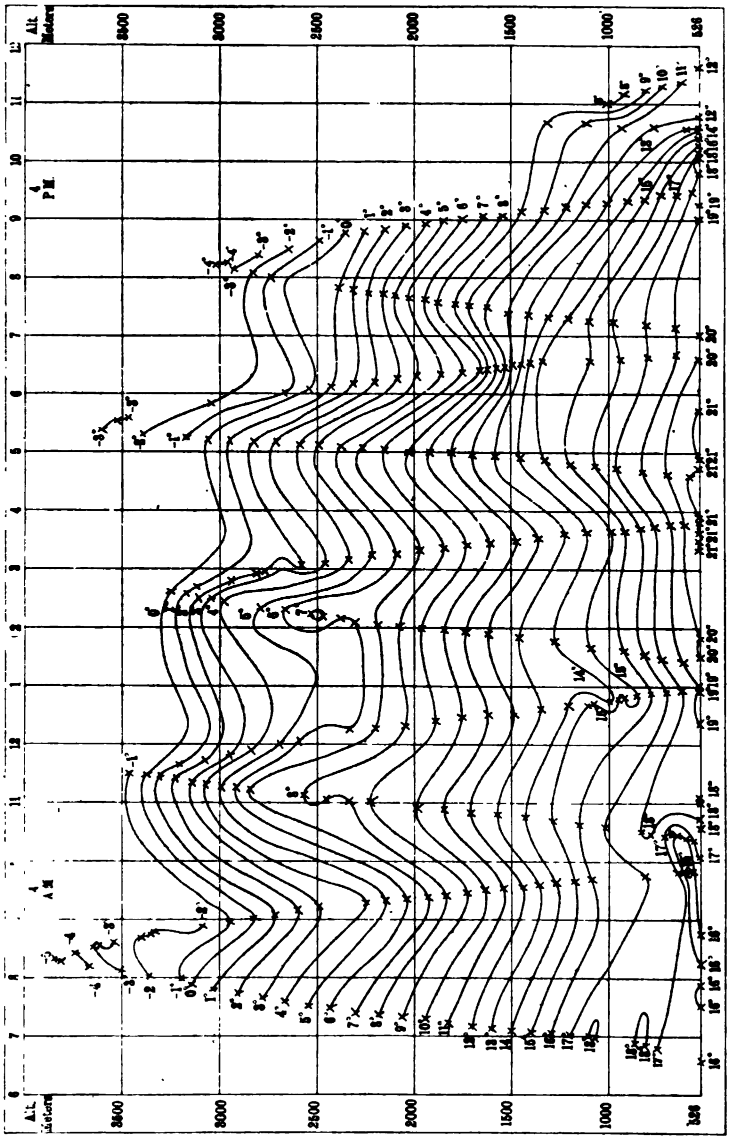

FIG. 68.—Free air isotherms above Mount Weather; observed April 4, 1913.

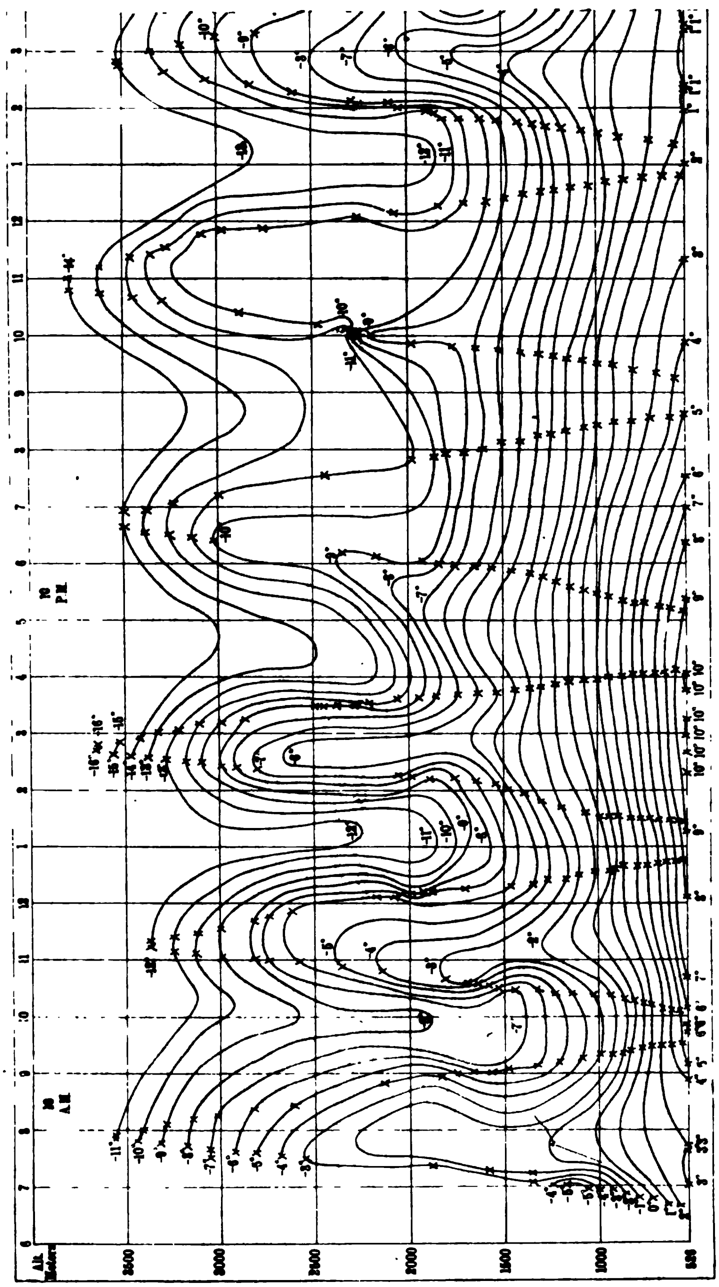

FIG. 60a.—Free air isotherms above Mount Weather; observed May 10, 11, 1913.

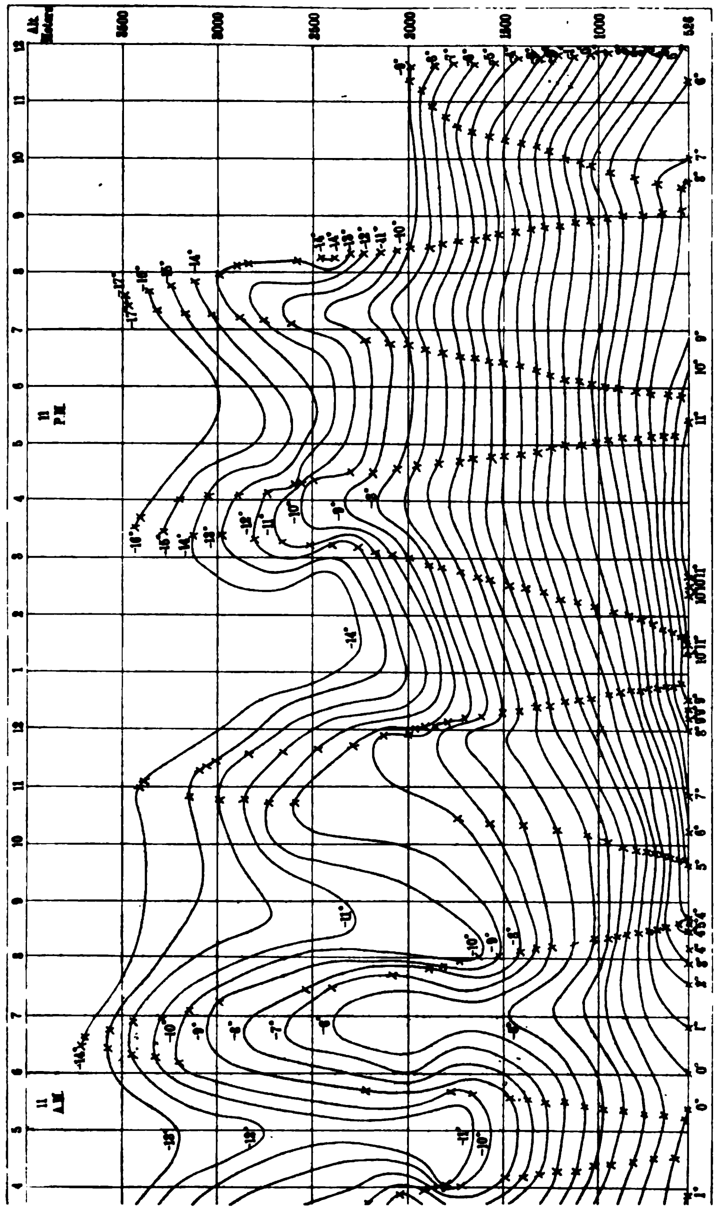

FIG. 69b.—Free air isotherms above Mount Weather; observed May 10, 11, 1913.

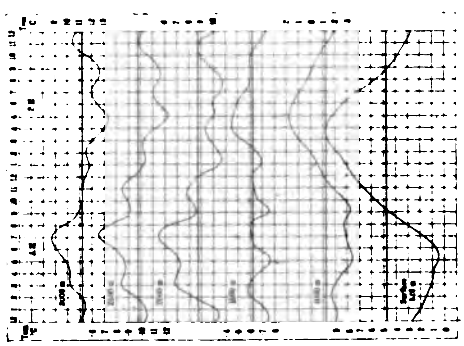

FIG. 70.—Smoothed diurnal curves of temperature above Mount Weather; observed 9.30 a. m., May 10, to 9.30 a. m., May 11, 1913.

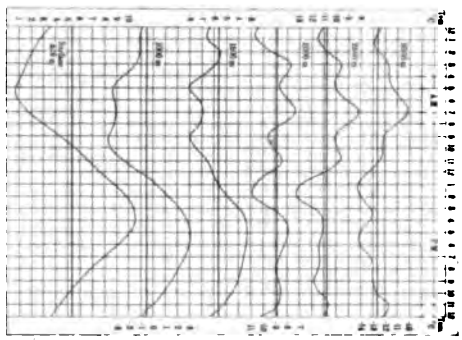

FIG. 71.—Smoothed diurnal curves of temperature above Mount Weather; observed 8.30 p. m., May 10, to 8.30 p. m., May 11, 1913.

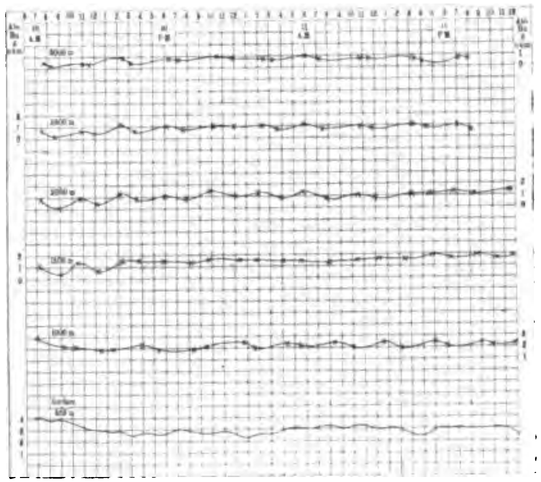

FIG. 72.—Absolute humidities above Mount Weather; observed May 10, 11, 1913.

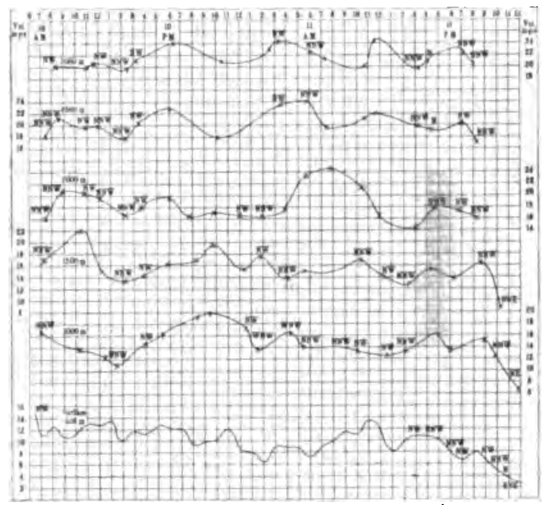

FIG. 73.—Wind velocities and directions above Mount Weather; observed May 10, 11, 1913.

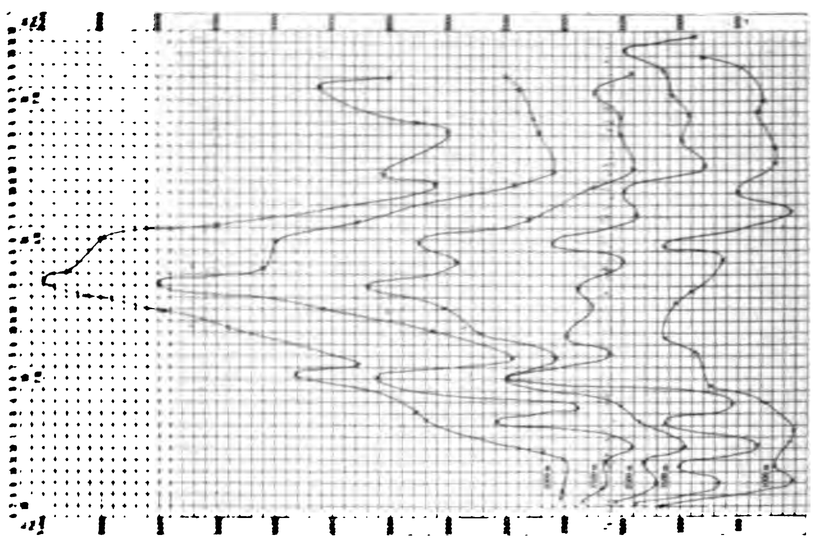

FIG. 74.—Atmospheric electric potentials above Mount Weather; observed May 10, 11, 1913.

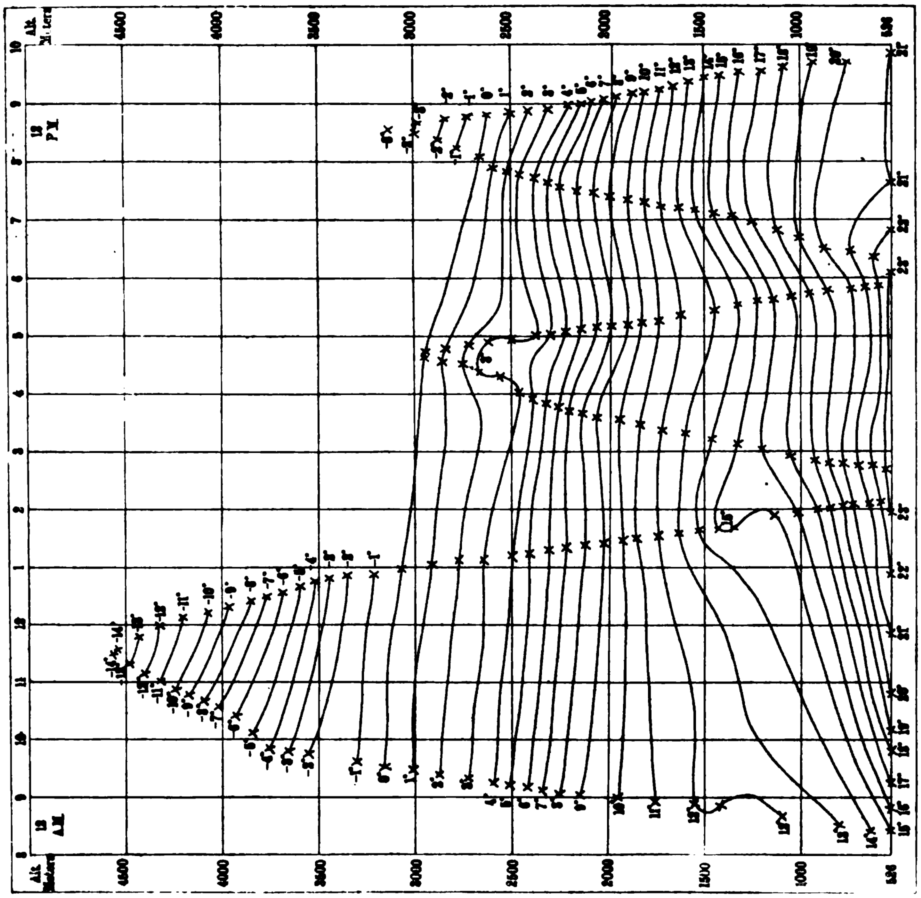

FIG. 75.—Free air isotherms above Mount Weather; observed June 12, 1913.

W. B. No. 526 Issued February 25, 1914

U. S. DEPARTMENT OF AGRICULTURE

WEATHER BUREAU

CHARLES F. MARVIN, Chief

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OF THE

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BULLETIN

OF THE

MOUNT WEATHER OBSERVATORY

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W. B. No. 526. CLEVELAND ABBE, Editor. Issued February 25, 1914.

8. OBSERVATIONS ON THE INCREASE OF INSOLATION WITH ELEVATION.

HERBERT H. KIMBALL.

[Dated Mount Weather, Va., Nov. 20, 1913.]

Between August 30 and September 2, 1909, inclusive, four series of simultaneous pyrheliometric readings were obtained at Mount Weather, Va., at an elevation above sea level of about 1,720 feet, and at Trapp, Va., at an elevation of about 720 feet. Trapp is approximately 1¼ miles east of Mount Weather, and is immediately at the foot of the Blue Ridge, on the summit of which is Mount Weather.

Nearly continuous readings were obtained from 3.45 p. m. to 5.15 p. m. of August 30, from 3 p. m. to 5.15 p. m. of September 1, and from 7 a. m. to 11.15 a. m. and again from 2.45 p. m. to 5 p. m. of September 2. Mr. W. R. Gregg read Ångström pyrheliometer No. 105 at Mount Weather, while Smithsonian pyrheliometer No. VIII, which is of the so-called copper box type, was read by me at Trapp.

These two instruments were also read simultaneously by us at Mount Weather on August 2, August 9, and September 2, 1909; and after reducing the readings of Smithsonian No. VIII to the revised Smithsonian scale the factors given in Table 1 have been obtained to reduce the readings of Ångström No. 105 to this same scale.

TABLE 1.—*Factor to reduce the readings of Ångström pyrheliometer No. 105 to the revised Smithsonian pyrheliometric scale.*

Date and time of comparative readings.	Number of readings.	Factor.
August 2, a. m.	12	1.108
August 2, midday	8	1.108
August 2, p. m.	8	1.089
August 9, midday	12	1.100
September 2, midday	12	1.089
Average factor		1.099

To obtain the radiation intensities given in Table 2, the data for both Mount Weather and Trapp have been plotted with the logarithms of the instrumental indications for ordinates and the air masses (approximately the secant of the sun's zenith distance) for abscissas. The most probable logarithms for the air masses given in the headings of Table 2 were read from these plots, and those for Ångström pyrheliometer No. 5 were increased by 0.0410, the logarithm of the factor 1.099.

TABLE 2.—*Comparison of solar radiation intensities at Mount Weather and Trapp, Va.*

Date and place.	Radiation intensities in gram calories per min., per cm². Air mass. 1.5	2.0	2.5	3.0	3.5	Polarization of sky light.	Temperature at Mount Weather.	Vapor pressure at Mount Weather.
1909.						*Per cent.*	*°C.*	*mm.*
August 30, p. m.:								
Mount Weather	....	1.152	1.056	0.985	....	....	21	9.24
Trapp	....	1.134	1.020	0.961	....	....	....	....
September 1, p. m.:								
Mount Weather	1.196	1.000	0.875	....	....	58	19 to 17	7.04 to 6.27
Trapp	1.149	0.936	0.814	....	....	....	....	....
September 2, a. m.:								
Mount Weather	1.392	1.289	1.190	1.092	1.007	67	9 to 12	6.63
Trapp	1.322	1.207	1.110	1.032	0.959	....	....	....
September 2, p. m.:								
Mount Weather	1.277	1.078	0.921	0.763	....	63	19	5.95
Trapp	1.230	0.990	0.852	0.703	....	....	....	....
	Trapp insolation divided by Mount Weather insolation.							
August 30, p. m.	....	0.984	0.966	0.975	....			
September 1, p. m.	0.960	0.936	0.930	....	....			
September 2, a. m.	0.950	0.936	0.933	0.946	0.952			
September 2, p. m.	0.963	0.919	0.925	0.921	....			
Average	0.958	0.944	0.938	0.947	0.952			

Some details of the prevailing atmospheric conditions at the times of observations have been included in Table 2.

The ratio $\frac{\text{Trapp insolation}}{\text{Mount Weather insolation}}$ is fairly constant from day to day. On the afternoon of August 30, which was a day with high absolute humidity but with a clear sky, the ratio was higher than the average. The ratio was lower than the average on the afternoon of September 2, which was a day with low absolute humidity at the surface, but with rapidly diminishing atmospheric transparency in the afternoon. The atmospheric conditions were unusually steady and favorable for comparisons of this character on the morning of September 2. There were a few cumulus clouds present on the morning of this day and on August 30, and light haze was recorded on September 1 and 2.

The factors given in Table 1 indicate that the ratios in Table 2 for individual series may be in error by as much as ± 0.01. We are therefore only justified in saying that under the conditions prevailing at the time the readings summarized in Table 2 were obtained, from 4 to 6 per cent of the insolation reaching the top of the Blue Ridge, at the 1,720-foot level, was absorbed before it reached the surface of the valley 1,000 feet below.

On October 25, 1912, simultaneous pyrheliometric readings were obtained about noon at Santa Fe and Twin Mountain, N. Mex.; and four days later, on October 29, 1912, simultaneous readings were obtained about noon at Santa Fe and Lake Peak, N. Mex.

Santa Fe is on a plateau approximately 7,000 feet above sea level. Twin Mountain is one of two peaks some 2½ miles southeast of Santa Fe that rise abruptly from the plateau to a height of nearly 8,000 feet above sea level.

Lake Peak is in the Rocky Mountain range about 11 miles northeast of Santa Fe, and rises to a height of approximately 12,200 feet above sea level.

Mr. J. B. Sloan read Marvin pyrheliometer No. VI at Santa Fe on both the above dates, while Smithsonian silver disk pyrheliometer No. 1 was read by me on the summit of the two mountain peaks.

The factor to reduce the readings of Marvin pyrheliometer No. VI to the revised Smithsonian scale was determined by comparing this instrument with Smithsonian No. 1. In Table 3 are given the ratios between the indications of the two instruments when read simultaneously, each ratio being obtained from the average of a series of readings, the number of readings of the Marvin instrument in each series being given in the table. The number of readings of the Smithsonian instrument was only half as many.

TABLE 3.—*Comparison of Marvin spiral pyrheliometer No. VI with Smithsonian silver disk pyrheliometer No. 1.*

Date.	Number of readings.	Ratio, $\frac{\text{Marvin.}}{\text{Smithsonian.}}$
1912.		
July 11	8	1.000
August 15	8	0.999
August 22	22	1.000
August 24	12	1.002
August 24	7	1.000
October 26	20	1.014

The radiation intensities given in Table 4 were obtained from the means of simultaneous series of readings, each series consisting of about 20 readings by the Marvin instrument and 9 readings by the Smithsonian instrument.

The ratios in Table 3, and especially the one for October 26, indicate that the radiation intensities given for Santa Fe may be relatively too high by as much as 1.5 per cent. We are therefore only justified in saying that on October 25, 1912, from 0.5 to 2 per cent of the insolation that reached the top of Twin Mountain, N. Mex., at an elevation above sea level of 8,000 feet was absorbed before it reached the plateau 1,000 feet below; and on October 29, 1912, from 2.5 to 4 per cent of the insolation reaching the top of Lake Peak, N. Mex., 12,200 feet above sea level, was absorbed before it reached the plateau more than 5,000 feet below.

It will be noticed, however, that the smaller percentages are proportional to the thicknesses of the absorbing layers.

TABLE 4.—*Comparison of midday solar radiation intensities at Santa Fe, Twin Mountain, and Lake Peak, N. Mex.*

Date.	Place.	Insolation per minute per square centimeter at midday.	Temperature.	Vapor pressure.
		Gram calories.	°*C.*	*mm.*
1912.				
Oct. 25	Santa Fe	1.481	15	4.60
Do	Twin Mountain	1.488	16	3.16
Oct. 29	Santa Fe	1.389	8	3.00
Do	Lake Peak	1.425	−1	2.30
RATIO OF INSOLATIONS.				
$\frac{\text{Santa Fe}}{\text{Twin Mountain}}$		0.995		
$\frac{\text{Santa Fe}}{\text{Lake Peak}}$		0.975		

On October 25, 1912, the atmosphere both at Santa Fe and at Twin Mountain was very clear and the sky was a deep blue. From the top of the mountain, however, the dust haze over the lower levels was distinctly visible.

On October 29 there were no clouds present at noon, but the sky in the direction of the sun was whitish, and the atmosphere over the valleys, particularly toward the south, had a hazy appearance. There was considerable smoke over Santa Fe during the morning of the 29th, but it had nearly disappeared by noon. There was little smoke over the city at any time on the 25th.

The air mass at the time of taking these observations was 1.50 on October 25 and 1.53 on October 29.

9. SUMMARY OF THE FREE-AIR DATA OBTAINED AT MOUNT WEATHER FOR THE FIVE YEARS, JULY 1, 1907, TO JUNE 30, 1912,

By the Aerial Section—WILLIAM R. BLAIR, in Charge.

[Dated Dec. 15, 1913.]

On 1,682 of the 1,827 days of this period 1,758 free-air observations, exclusive of pilot balloon soundings, were made. The meteorograph was carried up by kites 1,522 times and by captive balloons 236 times. Occasionally two or more observations were made on the same day, but during the first two years no observations were made on Sundays. For the first four years air temperature, air pressure, and wind direction aloft were observed, in addition to noting weather conditions and keeping the usual continuous meteorological records at the earth's surface. Throughout the fifth year relative humidity and wind velocity aloft were also observed.

THE METEOROGRAPHS.

The meteorographs used in obtaining the observations of these five years were of the Richard and Marvin types. The Richard instrument used recorded air pressure and air temperature only. The Marvin instrument recorded relative humidity and wind velocity in addition to air pressure and temperature. When properly calibrated either of these instruments serves its purpose well.

It has been found that the barometer needs especial attention in calibration. Some of the aneroids on the meteorographs used are less affected by variations in temperature than others, but the readings of all are influenced. The Bourdon tube has usually been found better than the cellular type of aneroid. To avoid this defect the instruments have been calibrated for pressure and temperature simultaneously. In any calibration the pressure and temperature are lowered at a rate approximately the mean for the season in which the instrument is to be used. In actual observation there are, of course, departures from this mean rate of decrease with altitude in pressure and temperature. The error from this source is not therefore entirely eliminated. It is, for the most part at least, brought within the limit of accuracy of the instruments as they must be used. A second source of error is found in that the aneroid requires a long

time for recovery after it has experienced such a change in pressure as is found between the base station and the upper levels reached in a kite or balloon ascension. To partially eliminate errors from this source, the calibration of the instrument was made to occupy approximately the time of an ascension. Occasional ascensions depart far from the mean in both the time required to make them and in their height, but in the great majority of cases departures are not so great as to require a special calibration of the meteorograph.

The hair hygrometer as ordinarily made, i. e., with the several hairs lying close to each other, was found to be very slow in responding to conditions as it experienced them. This was especially true when the element passed from a layer of moist to one of dry air. This slowness was to a large extent remedied by stretching the half dozen or more hairs used parallel to each other but not touching. Every hair is thus exposed. Some difficulty was experienced in mounting the hairs so that they would be taut at the same time and, consequently, under different conditions as to moisture content of the air in which they were exposed. Care in this particular was well repaid.

The hygrometer and the wind elements of the meteorograph were calibrated in surface conditions only and by comparison with the Marvin sling psychrometer or Assmann aspiration psychrometer and the Robinson anemometer, respectively.

With the above precautions, in addition to careful adjustment and use of the meteorographs, fairly consistent observations have been obtained throughout the five-year period.

AIR PRESSURE.

In this summary the air pressures have been used only in the determination of altitudes. Work on the relations that may be shown to exist among air temperature, humidity, movement, and pressure by the data obtained in these five years has been set aside until some additional needed data are acquired. These further observations are now being made.

MONTHLY AND SEASONAL MEANS OF TEMPERATURE AT DIFFERENT LEVELS.

The temperature observed on these 1,682 days have been grouped by months and by seasons, and means have been computed for levels 250 meters apart up to 7,250 meters above sea level. In these means each day's observations have been given the same weight. The observations are well distributed throughout their respective periods, and the means for each group fairly consistent up to and including the 4,500-meter level. At this level the number of days per month on which observations were made ranges from 7 in August to 21 in

October and averages 12. Above this level the spring and autumn observations are more numerous than those of summer and winter.

Tables I and II show the mean free-air temperatures above Mount Weather—Table I the monthly mean and Table II the seasonal and annual means. Under each month in Table I are three columns. The first contains the number of observations at each level considered, or the weights of the means; the second, tne mean free-air temperatures; and the third, the mean change in temperature per 100 meters of altitude. A similar arrangement obtains in Table II.

The temperature data obtained in the five-year period are so arranged in figure 1 as to show the annual march of the mean monthly temperature at all levels explored. For the purpose of this chart three periods were considered in each month. The first and third periods of any month are its first and last 10 days, respectively, the days that are left constitute the second period. The temperature-altitude relation was plotted for each group of three adjacent approximately 10-day periods and the altitudes of the even degrees of temperature transferred from these plots to figure 1. A curve was then drawn through each set of points in figure 1 indicating the same temperature. No further attempt at smoothing has been thought advisable. It is easy for the reader to see where the smoother curves would go but it would be difficult for him to know in some cases which experimentally determined points belonged to a given curve if the curve did not actually pass through the points. It will be noted that the middle points in any month are the mean temperatures for the month at the levels indicated, and that the curves are very approximately curves of mean monthly temperature. The annual temperature maximum is found in July at the earth's surface, in August at the 4.5 kilometer level. At the surface the rise of temperature before the maximum is reached and the subsequent fall are on the whole fairly symmetrical, though in the months of May and June the rise of temperature is greater than the fall in the months of August and September. In the higher levels the fall of temperature after the maximum is considerably more rapid than the preceding rise. The zero curve of mean monthly temperature reaches the earth's surface in the first half of December and leaves it in the first half of February. Between these two points the mean surface temperature is less than, but differs little from, zero. At high levels January temperatures show a decided maximum, minima occurring in December and February.

The value of the five-year monthly means as normals depends on whether the five years in which the data were collected are average years and on the distribution, monthly and diurnal, of the observations. Instrumental and observational errors have been carefully guarded against.

In the miscellaneous Table III are given the available data more or less directly related to the temperature data shown in Tables I and II. All data in Table III are for the five years except those items marked with an asterisk (*), which are for only the last four years of the period. These data throw some light on the peculiarities of the period under consideration and on the diurnal distribution of the free-air observations.

The first line of Table III shows the mean surface temperature of each month for the five years at Mount Weather. The second line shows the Mount Weather monthly means reduced to a 38-year period by comparison with the temperature observations at Washington and Lynchburg. The corrected temperatures are lower in the late winter and spring months and higher in the summer months than the observed temperatures. The greatest negative correction, $-2.6°$, is needed in March and the greatest positive correction, $+1.0°$, is needed in June. The annual correction, $-0.4°$, is in the same sense but twice as large as the annual correction needed in the three-year summary. The data in lines 10 to 17, Table III, have to do with the peculiarities of the period. A comparison of the data in these lines for the three (see this Bulletin, Vol. IV, pt. 2) and five-year periods shows a general decrease in the mean duration of actual sunshine, a general increase in the mean cloudiness and in surface wind velocity. The only marked exception to this general trend is found in the month of May. In this month the mean duration of sunshine is 14 hours more in the five than in the three-year period, the cloudiness is 5 per cent less and there is no change in wind velocity. The monthly temperatures for the five-year period are a little higher than those for the three-year period in the summer months, a little lower in the winter months. None of these monthly differences much exceeds half a degree except those of March and November, in which the temperatures for the five-year period are 1.7° and 1.5° lower, respectively, than those of the three-year period, and of May in which there is a difference of 1.2° in the opposite sense.

In March and November the decrease in mean duration of sunshine from the three to the five year period was 17 hours per month; the increase in mean cloudiness was 3 and 4 per cent and in wind velocity 0.6 and 1.6 m. p. s., respectively. The greatest increase in wind velocity for any month is 1.6 m. p. s. The most marked change in mean surface wind direction is found in August. The mean is N. 69° W. in the three and S. 42° W. in the five year period. This more southerly wind is accompanied by the greatest decrease in mean duration of sunshine, 36 hours, the greatest increase in mean cloudiness, 7 per cent, but by no marked change in temperature, an increase of 0.3° only. At higher levels no marked change in wind direction

from the three to the five year periods is observed. The greatest change to the south of the prevailing westerly wind in the 2,000 meter level is 12°, found in the August and October means; to the north in the same level is 7°, in the February means. The weights of the means given in lines 14 to 17 of Table III may be found in Table I.

The distribution of the observations in any month is fairly good up to the 4.5 kilometer level—better at the lower than at the upper levels.

The diurnal distribution of the observations is not so good. Considering the time at which the highest point was reached as the time of observation, practically all observations are included in the hours 6.30 a. m. to 10.29 p. m. The observations not included between these hours were made in August and September, 1911, and in March, 1912. In each of these months one 24 or more hour series of ascensions was made. If observations made between 6.30 a. m. and 7.29 a. m. be called 7 a. m. observations, those between 7.30 a. m. and 8.29 a. m. be called 8 a. m., etc., there will be found two maxima in the number of observations, one occurring at about 10 a. m. and the other at about 3.30 p. m. The sixth and seventh lines of Table III show for each month the percentage of observations made from 6.30 a. m. to 12.29 p. m. and the mean time at which they were made. The eighth and ninth lines contain similar data for the observations made from 12.30 to 10.29 p. m. According to the observations now in progress at Mount Weather on the diurnal variation of temperature and other elements, the mean time of the forenoon observations is very close to the time when a free air observation by means of kite or balloon will give the best approximation to mean temperature conditions for the day. The mean time of the afternoon observations is just a little past the time of the diurnal temperature maximum at the earth's surface. Line 4 of Table III shows the corrections to be applied to the indications of the kite meteorograph in order to get the mean temperatures indicated by the station meteorograph. These corrections are all negative but in only three months are they as high as 1°. The mean correction for the year is $-0.5°$, for the months of May to September $-0.9°$ and for the rest of the year $-0.3°$.

Our experience with the diurnal range of temperature points to the conclusions that the negative correction at the 1,000-meter level will be but little if any over half that at the surface. At about the 1,500-meter level, the correction will be zero. Above the 1,500 to, at least, the 2,500 meter level there will be an increasing but always small positive correction to be applied to the indications of the kite meteorograph in order to get actual temperatures. All of these corrections are negligible, except those from the surface up to say the 1,000 meter level in the months of May to September, inclusive. It has been thought best to publish actual data in Tables I and II. The above considerations indicate that, with corrections in each month from May

to September as follows: Surface level, $-0.9°$; 750-meter level, $-0.7°$; 1,000-meter level, $-0.5°$; and with a correction at the surface level of $-0.5°$ in the months of March and April, the value of the means given in Tables I and II as normals is directly related to the number of observations and the peculiarities of the period in which they were taken.

FREE-AIR TEMPERATURE IN RELATION TO TYPES OF SURFACE-AIR PRESSURE.

The free-air temperatures for the different seasons have also been grouped with reference to the surface distribution of air pressure. Three general groups, one containing all observations made well within high pressure areas, another well within low pressure areas, and a third, those that could not be included in either of the first two, were considered. The air pressure reduced to sea level was usually above 764.5 millimeters of mercury in the first group, below 759.5 millimeters in the second group, and between these two pressures in the third. In the study of the air temperatures, the first and second groups are subdivided into quadrants numbered I, II, III, IV counterclockwise from the forward half of a line through the center and lying in the direction of motion of the high or low pressure area under consideration. In the third group the three subdivisions are based on the relative positions of the disturbances active at the station. They are: (1) Low pressure area NW., W., or SW.; high pressure area NE., E., or SE. (2) Low pressure area NE., or E.; high pressure area NW., W., or SW. (3) Low pressure area moving up the Atlantic coast; high pressure area N.

High-pressure areas moving in a variety of directions pass Mount Weather in such ways that observations are fairly well distributed in the different quadrants of the high and in the different seasons of the year. There is more uniformity in the direction of motion of the low-pressure areas as they pass Mount Weather, also more uniformity of path. The great majority of these areas pursue an east-northeasterly course well to the north of Mount Weather; some pass up the coast to the east. It follows that very few observations have been made in quadrants I and II of low-pressure areas, while quadrants III and IV are well represented. More observations have been made in quadrants II and III than in I and IV, respectively, owing to the better weather conditions.

Tables IV, VI, and VIII show the means of the temperature observations made in the above-described groups at levels 250 meters apart up to 7,250 meters above sea level. In Tables V and VII, quadrants I and IV, and II and III have been combined and the mean temperatures for the different seasons shown of high and of low pressure areas, respectively. With each column of mean temperatures in

any table is a column showing the weights of the means and one showing the mean change in temperature per 100 meters of altitude. Figures 2 to 5, 6 to 9, and 10 to 12 are, respectively, graphic representations of the data in Tables IV, VI, and VIII. To the right and at the foot of each curve in these figures is the number of observations represented in the mean, while below is the temperature of the point common to the curve and the base line.

Comparison of the means shown in these tables and figures with the means found in the summary of the first three years' observations emphasizes the conclusion that they are quite characteristic of their respective groups. Whether or not they represent actual mean conditions in their respective groups will depend upon the number of observations in any group and upon considerations already discussed in connection with the mean monthly temperatures at the different levels. Of the latter the diurnal distribution of the observations from which the means are computed is the most important. Corrections on account of this distribution are needed in the lower levels only.

The temperature gradient in high-pressure areas is decidedly larger for the first than for the second 500 meters above the mountain top. The same effect is noticeable in the quadrants II and III of the low-pressure areas but is apparently absent in quadrants I and IV. This effect is probably accounted for by the fact that the observations were made near the diurnal maximum of temperature. The diurnal maximum of temperature is least prominent in the usually cloudy quadrants I and IV of the low-pressure area, more prominent in the other regions mentioned.

In those levels between 1 and 2.5 kilometers above sea level, i. e., 0.5 to 2 kilometers above the mountain top, the temperature gradient is smaller than either above or below these limits. In both high and low pressure areas this phenomenon varies from being hardly noticeable in the clearer summer months to being very pronounced in the winter months. If this peculiarity of the temperature gradient is accounted for by condensation of moisture in the levels considered, its variation with the seasons may be accounted for by the relatively greater (vapor content of the air considered) condensation taking place in these lower levels in the winter than in the summer months. It may be remarked that the inversion of temperature in these levels is as persistent from day to day throughout the winter months as is the upper inversion of temperature, found in this country to begin at about 15 kilometers above sea level. (See this bulletin, Vol. IV, pt. 4.)

The temperature gradient between the 2.5 and 4 kilometer levels is less variable from season to season and from quadrant to quadrant than that of the lower levels. In high-pressure areas at these levels

the variation from the mean of 5.2° per kilometer is always less than 1°, the groups by quadrants and seasons considered. In low pressure areas the variation from the mean of 5.8° per kilometer is frequently greater. The winter gradient at these levels is on the average the same in the high as in the low pressure areas, while the summer gradients show the greatest mean difference. All levels considered, summer temperature gradients are the largest and winter temperature gradients the smallest, whatever group is considered.

MOUNTAIN AND VALLEY TEMPERATURES IN THE VICINITY OF MOUNT WEATHER.

In order to extend the temperature observations to lower levels than the mountain top and to study the effect of topography on the distribution of surface temperature in this vicinity, cooperative stations were established, one in the middle of either valley and one at the foot of the ridge on the east side. Audley is about 13 kilometers to the northwest and Benton's about the same distance to the southeast of Mount Weather. Trapp is about 2 kilometers to the east-southeast of Mount Weather. None of these stations lies far from a line through Mount Weather and at right angles to the direction of the ridge. Their heights above sea level are 152, 137, and 217 meters in the order named above, while Mount Weather is 526 meters above sea level. The slope of the ridge on the southeast side is fairly steep, that on the northwest side is considerably less steep and broken by foothills. Audley is a somewhat more exposed station than Benton's and the mean temperature is slightly lower. Temperatures at Audley and Benton's are both lower on the average than those at Trapp. The first two stations have the characteristic diurnal variation of valley stations, i. e., a wide range of temperature, especially on clear days. The diurnal variation at Trapp, while differing somewhat in type from that on the mountain top, is more like the latter than it is like that of the valley stations. Trapp may be called a slope station. Its temperature is nearly always above that of Mount Weather and in the means differs from Mount Weather by about 5/7 of the adiabatic rate for dry air. On clear quiet nights there is sometimes an inversion of temperature between Trapp and Mount Weather. Under these conditions there is always an inversion between the valley stations and Mount Weather. An inversion of temperature between the low and high level stations is never found in cloudy weather. When a high-pressure area is passing, the temperature at Mount Weather usually reaches its minimum in the west to northwest wind in front of the maximum air pressure. The temperature at the valley stations usually reaches its minimum in the clear, calmer conditions that accompany the passing of the

maximum air pressure. The valley minimum is lower than the Mount Weather minimum when the above conditions of air pressure are well defined. The temperature at Trapp is probably less influenced by the peculiar topography than that at either Audley or Benton's. It has therefore been used in extending the free-air isotherms below the Mount Weather level.

The temperature differences between the valley stations and Mount Weather do not depart far from the normal order except, as noted above, in clear, quiet weather. Whether the extraordinary temperature differences existing at such times owe their occurrence to large departures from the normal of the valley or of the mountain temperatures, or to both, and how far under clear, quiet conditions the Mount Weather temperatures depart from free-air temperatures at the same level, are questions of interest in connection with the upper-air work. The extremes of temperature in the valleys are of interest especially in the spring and autumn months, the seasons of late and early frosts. In order to get a quantitative idea of the relations existing between the mountain and valley stations on clear, comparatively quiet days, the hourly temperatures on all such days for the year, July 1, 1910, to June 30, 1911, have been considered. The clear days of this year have also been used in a later consideration of absolute humidity in the valley and on the mountain.

These temperatures are so charted in figure 33 as to be readily compared. The thermometers at all stations were exposed in louvered shelters and about 2 meters above the earth's surface. The temperatures recorded by these thermometers are those referred to as the mountain and valley temperatures.

The following are some of the facts shown in figure 33 that should be noted as characteristic of clear and comparatively quiet atmospheric conditions: While the Trapp temperatures are always above those of Mount Weather, they are farthest above at about the time of the diurnal maximum. The Trapp maxima and minima lag a little behind those of Mount Weather. The Audley temperatures have a higher minimum and a lower maximum daily temperature than have those of Benton's except in the summer months. The diurnal minima at both the valley stations are more sharply defined than those of either Trapp or Mount Weather. The maxima of the valley stations are not so sharply defined as the minima and are above the Mount Weather maxima by nearly the adiabatic rate. Benton's is shown to be the more characteristic valley station, Audley having to a limited extent slope station characteristics. In the spring months the Benton's and Mount Weather temperatures are the same at 7.45 a. m. and 8.45 p. m., in the summer at 6.45 a. m. and 9.20 p. m., in the autumn at 8.20 a. m. and 6.50 p. m., and in the winter at 10.10 a. m. and 5.45

p. m. The difference in temperature between Benton's and Mount Weather is nearly constant and but little less than the adiabatic rate between the two stations from 9 a. m. to 5 p. m. in the spring and in the summer months, from 9 a. m. to 4.30 p. m. in the autumn, and from 12 noon to 4 p. m. in the winter. (Free-air observations at Mount Weather indicate that on clear, quiet days the approximately adiabatic rate of temperature decrease obtains to a height of several hundred meters above the mountain top.) The Mount Weather diurnal maxima and minima are, as a rule, a little later in the day than those of Benton's. The differences between the Mount Weather and Benton's minima are 4.4 degrees centigrade in the spring months, 1.6 in the summer, 3.8 in the autumn, and 5.7 in the winter. The diurnal range at Benton's is 18.3 degrees centigrade in the spring months, 13.1 in the summer, 17.5 in the autumn, and 15.9 in the winter.

The most influential factors in the determination of these temperatures are insolation, terrestrial radiation, and topography. Prof. Kimball has made some simultaneous observations of insolation at Trapp and Mount Weather. It appears from these measurements that on clear days the insolation at Trapp is about 95 per cent of that at Mount Weather. Terrestrial radiation when measured on clear nights seems to vary, within certain limits, rather directly with the absolute humidity. (See A. Ångström, The Astrophysical Journal for June, 1913.) Unfortunately, only the dry-bulb thermometer was read at the valley stations. Both wet and dry bulb were read at Trapp during part of the time that station was in operation. The 8 a. m. psychrometer observations for one year at Trapp have been reduced. The mean for the year, all days considered, is 7.5 grams per cubic meter at Mount Weather, and 8 grams per cubic meter at Trapp. The maximum values 13.9, and 14.7, respectively, are found in July; the minimum, 2.7 and 3.1, in December of the year selected (July 1, 1910, to June 30, 1911). These values can not be used in applying Ångström's observations, all of which have been made on clear nights, but they serve for an interesting comparison with the corresponding values for the clear days of this year. Clear days considered, the means for the year are 6.6 and 7.2; the maximum values, 13.8 and 14.7; and the minimum values, 2.2 and 2.3. The maxima and minima at both stations occur in July and December. Ångström's observations were not of sufficient range to cover all of these humidities, but applied to the mean values and to the months as far as they go (May to October) terrestrial radiation at Trapp is found to be 97 per cent of that at Mount Weather in the year and to vary by less than a half of 1 per cent from this value in any of the months mentioned. It is probable that the values of the absolute humidity at the valley stations are somewhat higher than those at Trapp. If they are, the

ratio of the nocturnal terrestrial radiation at the valley stations to that at Mount Weather will be larger than that between Trapp and Mount Weather. The indications are that this ratio is between 95 and 97 per cent.

The radiation from the earth to the sky has been observed more frequently at night than during the day. It is probable that in the warmer hours of the day the earth is receiving heat from the sky, though observers differ on this point.

That 5 per cent of the solar radiation received at Mount Weather should be absorbed or reflected by the air mass between the Mount Weather and valley levels is an interesting fact, and one that should be supported by more extended observation. The air in a perpendicular column of 1 square centimeter cross section and extending from the Trapp to the Mount Weather level is only about three-tenths of a cubic meter in volume, or about thirty-five hundredths of a gram in weight. It is readily seen, therefore, that if only a small part of this 5 per cent of the insolation at Mount Weather is absorbed by the air between these two levels the heating during a clear day would be very great.

Measured in calories per square centimeter per minute, nocturnal terrestrial radiation at Mount Weather on a clear night is probably 0.18 to 0.2, or about 15 per cent of the maximum solar radiation received at the earth's surface on a clear day. It seems that very approximately this ratio between insolation and nocturnal terrestrial radiation also obtains at the valley stations. Observations of nocturnal terrestrial radiation at different altitudes have recently been made by A. Ångström. These observations have not yet been fully reduced, but in Ångström's opinion they indicate a large absorption of terrestrial radiation by the water vapor of the air below the 1 kilometer level. This being the case, a large percentage of the heat energy in that part of the terrestrial spectrum absorbed by water vapor will be absorbed by the air in the valley below the Mount Weather level.

The air at the earth's surface on the mountain top and slopes and in the valley will be cooled on a clear, quiet night by contact with the earth, and, since the latter is losing heat more rapidly on the mountain top than in the valley, the air on the mountain top will be in contact with the colder surface.

It has been shown that the air mass between the Mount Weather level and the bottom of the valley becomes heated on a clear, quiet day to as high a temperature as convective mixing with air at higher levels will permit; and that nocturnal terrestrial radiation, while cooling the earth's surface and a thin layer of air in contact with it, tends to maintain the high temperature of this air mass throughout the night. In a quantitative consideration of this heating, radiation

from the air mass itself would need to be considered. The rapid cooling in the thin surface layer of air, together with the very slow cooling in the layer immediately above it, gives rise to a sharp inversion of temperature, probably amounting in the early part of a clear, quiet night to 8° or 10° C., with the maximum temperature in the free air at one to two hundred meters above the valley floor. A balloon observation in the free air above the valley on a clear, quiet night would be interesting in this connection. While none has been made or is now possible before next spring in this particular location, we have made balloon observations in somewhat similar conditions of atmosphere and topography. These observations were made in southern California and in the time between sunset and 11 p. m. Inversions of temperature of 7° to 11° C. were found between the earth's surface and the 150 to 175 meter level. The continued increase through the night of this temperature inversion above the valley station is checked by the convective interchange which must take place as soon as the cooling of the air on the mountain top or slopes has established the requisite temperature difference between itself and the stratum of air at or below its level and above the valley having the highest potential temperature.

It follows that on clear, quiet days the diurnal extremes of temperature at Mount Weather, which would otherwise be more pronounced than those of the valley stations, are tempered—in the daytime by convective interchange of the warm surface air on the mountain top with the cooler free air at the same and at higher levels; in the nighttime by convective interchange between the cool surface air on the mountain top and the warmer free air at the same or at lower levels. The same may be said of any slope station, the only difference being that in the case of a slope station the tempering effects will not be so marked. At a station in the bottom of the valley the diurnal maximum of temperature will be tempered by convective interchange of the warm surface air with the cooler free air at higher levels. The diurnal minimum at such a station is but little (depending on the slope of the valley floor) directly affected by any convective interchange of air. The indirect effect of the convection going on in the warmer layer immediately above the surface stratum must be small, since cooling in this layer could only affect conduction and radiation potential differences.

An interesting characteristic of the Trapp thermograms on clear, quiet nights is the irregularity of the curve as it descends to the diurnal mimimum. Irregular fluctuations of 1 or 2 degrees in temperature at irregular intervals of less than an hour are indicated. These fluctuations of nocturnal temperature are found to be characteristic of slope, but not of valley stations. They indicate that there is not a stream

of cool air past the slope station, but a direct convective interchange between the cool air on the slope and the free air over the valley and at the same or slightly lower levels. It is readily seen that this convective circulation will be tangent to the earth's surface at all points on the slope of the mountain, and that it will account for the movement at irregular intervals of warm and cold air past any point on the slope. There seems at no time during the day or night to be any convective interchange between the air masses in which the thermometers at the mountain and valley stations are exposed. As the comparative data given above for clear, quiet days indicate, the temperature differences between these air masses are of the right sign for convective interchange during only a part of the day, i. e., nearly as long as the period of insolation but beginning one and one-half to three hours later than sunrise and ending from three-fourths to one and three-fourths hours later than sunset. During this time the Mount Weather temperatures are somewhat higher than those of the free air at the same level. Consequently, convective interchange will be between the air about the valley station and the free air above it rather than with the surface air of the mountain top.

The above interpretation of the mountain and valley data should hold for hills of such height that their tops are higher above the plain or valley floor than the depth of the thin layer of air that is cooled at night by conduction of heat to the cool surface of the earth. For very small differences in elevation, i. e., for differences well within this thin surface layer of air, and for differences of elevation connected by very gentle slopes, the cooling of the air on the tops and slopes by conduction to the cool earth surface and by radiation will more than offset the adiabatic heating of the air in its slow descent, and the phenomenon sometimes called air drainage will result. Such a flow of air does not, as has been pointed out above, take place on the steeper slopes. Under given conditions it should be possible to determine the limiting height of a hill, also the limiting steepness of a slope below which the phenomenon will be drainage and not the convective interchange between surface and free air above described. This flow of air down gentle slopes is started by the unequal cooling of the earth's surface which in turn owes its existence to inequalities in terrestrial radiation. It takes place along stream and river beds and may be observed on plain as well as on valley floors. So long, therefore, as the valley is fairly open but little if any difference will be found between its hourly temperatures on clear quiet days and those of a near-by plain at the same level. The differences found will be owing largely to the constitution of the air above the stations compared. This statement will

not apply to a basin from which there is no outlet. In the bottom of such a basin, because of the entire lack of drainage, the diurnal minimum of temperature will be lower than that of either valley or plain at the same level.

In answer to the questions raised earlier in this discussion on mountain and valley temperatures it must be concluded:

1. That the surface air temperature on the mountain top on clear quiet days departs from the temperature of free air at the same level positively as a result of the heating of the earth's surface by insolation and negatively because of the cooling of the earth's surface by nocturnal terrestrial radiation, but these departures are limited to just such temperature differences as are needed to start the convective interchanges described above between the surface air on the mountain top and the free air at the same or higher levels during the day, at the same or lower levels during the night. This statement is in general applicable to the temperature observed at a slope station.

2. Simultaneous measurements of terrestrial radiation and additional measurements of insolation on clear quiet days at the mountain and valley stations are needed before it can be decided whether or not the mountain has at such times any effect on the valley temperatures aside from its effect as a barrier to atmospheric circulation. Such an effect if it exists will be small in the vicinity of Mount Weather since the ratio between insolation and terrestrial radiation is practically the same on the mountain top and in the valley. Comparison of valley temperatures with those of the adjacent mountain tops and slopes rather than with the temperatures of near-by plains of about the same elevation seems to be largely responsible for the idea that the diurnal minima in the valley are abnormally low under clear quiet atmospheric conditions.

OBSERVATIONS OF HUMIDITY DURING THE FIFTH YEAR OF THE PERIOD.

Tables XVII to XXI show the variations observed in absolute humidity with surface air pressure, time of the year, and altitude up to 3 kilometers. In every case the number of observations is shown with their mean. Figures 29 to 32, inclusive, illustrate parts of Tables XVII to XXI. In the preparation of these tables and figures the observations for each month were grouped into those made in the front half of a high-pressure area (H_f), those made in the rear half of a high-pressure area (H_r), those made in the front half of a low pressure area (L_f), and those made in the rear half of a low pressure area (L_r). There appeared some similarity of moisture distribution in the first and fourth groups, i. e., in the region of

rising surface air pressure (H→L), and in the second and third groups, i. e., in the region of falling surface air pressure (L→H). Means have therefore been shown in the tables for the groups H→L and L→H. Means of all observations made in the high pressure areas (H) and in the low pressure areas (L) have been put in the tables for the convenience of those who may have occasion to use them, also the means of all observations regardless of surface air pressure.

The shapes of the curves in figure 29 are more characteristic of their component observations than the numerical values of their abscissae. The latter vary through rather wide limits. Evidence of this is found in the deformations of some of the curves at the the upper levels where the number of observations has begun to fall off rapidly.

The curves for the spring and autumn months, figure 31, are similar both in form and position. The curves for the winter and summer are very different in both respects. The decrease of moisture content with altitude is greater near the earth's surface in the summer months, while in the winter months this greatest decrease is found at about the 2.5 or 3 kilometer level. Comparison of figures 29 to 32 with figures 2 to 12 indicates that the types of moisture content distribution described accompany certain types of temperature distribution, which, in their turn, are closely related to surface air pressure.

The variety of form and position shown by the curves in figures 29 to 32 bears out the statement made in this Bulletin (Vol. V, p. 21) with reference to formulæ for approximating the amount of water in the atmosphere above a given area of the earth's surface. These formulæ are based upon an observation of the absolute humidity at the earth's surface. While they may be of value as concise approximate expressions of mean conditions, they can not be expected to give even roughly approximate values for particular times or conditions.

WIND DIRECTION AT THE DIFFERENT LEVELS IN RELATION TO THE SURFACE AIR PRESSURE.

The wind directions as observed at the different levels during the five-year period have also been grouped with reference to surface air pressure. The three pressure groups already described in the consideration of the relation of temperature distribution in the free air to surface air pressure have been used. The same subdivisions of the third pressure group are also used, but in the first and second pressure groups the subdivisions are the octants numbered 1, 2, 3, 4, 5, 6, 7, 8, counterclockwise from the forward half of a line through the center and lying in the direction of motion of the high or low pressure

area. Each octant is further subdivided into observations made within 500 kilometers of the center of the disturbance under consideration, those made between 500 and 1,000 kilometers from the center and those made outside of 1,000 kilometers from the center.

Figures 13 to 20, inclusive, show the means of the wind directions observed in high-pressure areas at the surface and at higher levels. The number of observations included in any mean is indicated to the left of the red arrow representing that mean. Figures 21 to 28 show similar means in low-pressure areas. The number of observations is indicated as in figures 13 to 20. Tables IX to XIV show those wind direction observations made during the last two years of the five-year period, when the surface air pressure was more than 759.5 and less than 764.5 millimeters of mercury. Wind observations in this group for the first year have appeared on pages 148 to 150, Volume II, of this Bulletin, and for the second and third years on pages 43 to 49, Volume IV.

The large arrow across the face of each figure, 13 to 28, points the direction of motion of the high or low pressure area in which the observations were made. Of all high-pressure areas in which observations were made during this five-year period, 2 per cent were moving north, 8 per cent northeast, 10 per cent east-northeast, 32 per cent east, 20 per cent east-southeast, 13 per cent southeast, and 15 per cent south at the time of observation.

Of the low-pressure areas, the percentages moving in these directions were 2, 30, 23, 37, 4, 3, and 1, respectively. The relation between wind direction and the direction of motion of the disturbance considered is fairly characteristic both in the high and in the low pressure areas. The large arrows, showing directions of motions of the high-pressure areas, have therefore been superposed and mean wind directions found in each of the three subdivisions of each octant. The same plan has been followed in obtaining the mean wind directions shown in the low-pressure areas. Tables XV and XVI supplement figures 13 to 28, Table XV, for high-pressure areas and Table XVI for low. In each of these tables there are two columns for each level considered. The first column shows the number of observations made. The second shows the angle in degrees between the arrows showing the mean of these observations and the tangent at the point of the arrow to a circle about the center of the high or low pressure area considered. In Table XV, if an arrow has a component toward the center of the high-pressure area, the angle it forms with the tangent at its point is negative. In Table XVI, if an arrow has a component away from the center of the low-pressure area, it forms a negative angle with the tangent at its point. Table XV shows a sharp change in the value of these angles between octants VI and VII. The same

sharp change is indicated in Table XVI between octants II and III, but the number of observations in this part of the low-pressure area is small. Elsewhere in the high and in the low pressure areas the change in the value of the angles is more gradual.

By thinking of the red arrows in figures 13 to 28 as tangent to the lines of flow of the air in high and in low pressure areas, one is able to follow these lines in a general way. They are fairly well-defined spirals at the earth's surface, although, as far as they may be followed, none of these spirals subtends an angle at the center of the area of more than 180° and most of them subtend smaller angles. Above the 2-kilometer level, the lines of flow no longer have the spiral form, but indicate merely a deflection to the left of the center of high and to the right of the center of low pressure areas. This deflection is less marked in the higher levels. The sixth and seventh octants of the high-pressure area is a region of comparatively dead air. At the earth's surface the motion of this air mass may be decidedly opposite to the direction of motion of the area, usually depending on the intensity of the disturbance as measured by the barometer. At levels above 2 kilometers its motion is with the direction of motion of the area and apparently increasing in velocity with altitude. A similar condition is indicated in octants II and III of low-pressure areas, but the observations made in these octants are few in number.

OBSERVATIONS OF WIND DIRECTION AND VELOCITY DURING THE FIFTH YEAR OF THE PERIOD.

The wind directions, observed to 16 points, for this year have been considered in making figures 13 to 28 and Tables IX to XVI. In this particular part of the discussion they are considered with the observed wind velocity for the purpose of getting the resultant air movement.

In all, 550 simultaneous observations of the direction and speed of air movement were made at the 1-kilometer level. This number decreases with the altitude of the level considered. Of these 550 observations, 172 were made in the spring months; 133, in the summer; 113, in the autumn; and 132, in the winter. Observations of wind velocity could be made when the meteorograph was carried by a kite and not when it was carried by a captive balloon. Two observations were made on every day possible at all levels that could be reached by means of the kites. The cause of failure to obtain observations on a summer day was usually the absence of sufficient air movement in which to fly the kites. On a winter day the failure was usually accounted for by too much air movement, though occasionally by too little.

A kite flight started in an easterly wind in the summer months usually reached the top of the easterly current and no higher. Between this easterly wind and the westerly wind above it there is a stratum of a kilometer or more in thickness in which there is little or no air movement. In the winter months this stratum is not so thick nor is it altogether lacking in air movement. It nearly always happens that the kites rise through it or may be thrown up through it into the westerly wind above by reeling them in a short distance at high speed.

In this vicinity, at the earth's surface, summer winds have about half the average velocity of winter winds and the easterly winds have a much lower velocity than the westerly. It follows that in the summer months observations in easterly winds are, relatively, less numerous than those in westerly winds. It is also true that, whatever the season, precipitation occurs mostly in winds the direction of which is easterly. Sometimes precipitation prevents kite flying; at other times the flights are lower because of it.

These limitations on the method of observation are mentioned because of their effect on the distribution of the observations. They need to be kept in mind in considering the reduced data found in Tables XXII to XXVII.

Tables XXII and XXIII show the frequency and mean velocity of the differently directed winds observed at selected levels above Mount Weather for each season and for the year. The numbers in Table XXII show for the year the percentage of the winds observed at each level that were blowing from each of the 16 points. It appears from this table that northerly and southerly winds are relatively more frequent at the 1 to 1½ kilometer than at other levels. Easterly winds are relatively more frequent at the surface than at other levels, while westerly winds increase in relative frequency with altitude as far up as these explorations go. Tables like XXII have not been made for the different seasons, but in a general way the deductions from it hold for all seasons. Seasonal peculiarities in the frequencies of the differently directed winds observed at the different levels may be seen in the numbers of observations shown in Table XXIII.

The mean velocity of all winds from any of the 16 points observed at any level is shown in Table XXIII for each season and for the year. A fairly rapid increase of velocity with altitude from the earth's surface up to about the 1-kilometer level seems to be characteristic of all winds whatever their direction. It appears that the higher the wind velocity, the farther up this rapid increase in velocity extends. Above the 1-kilometer level, westerly winds increase rather steadily in velocity as far up as these observations go. North-

erly and southerly winds seem usually to reach their maximum speed at about the 1½-kilometer level, while the maximum speed of easterly winds is usually found below this level. These remarks on Table XXIII have general application. The most noticeable seasonal peculiarity is the lower speeds of the winds at all levels explored in the summer than in the winter months. Minor seasonal peculiarities appear to be related to this more prominent one.

Tables XXII and XXIII may contain data of value to those interested in aerial navigation. It appears in Table XXII, for example, that more than 90 per cent of the winds observed at the 2-kilometer level have a positive west component. Such winds are relatively less frequent below this level and more frequent above it. Increasing uniformity in the direction of the air movement at the higher levels is accompanied by increasing uniformity in the rate of this movement and therefore by less necessity for vertical air currents. The behavior of the kites in flight also indicates that the disturbed condition of the air near the earth's surface which may be accounted for by the topography and by unequal heating is seldom found above the 2-kilometer level.

The component and resultant air movement observed at the different levels are shown in Tables XXV to XXVII. In order that these data may be seen in their relation to air pressure at the earth's surface as well as to the general circulation of the atmosphere they have been grouped according to the wind directions at the 1-kilometer level as well as by seasons. The relation existing between the wind direction at the 1-kilometer level and the air pressure at the earth's surface, Table XXIV, is sufficiently close and definite for the purpose of this discussion. The headings in Table XXIV, H_1, H_2—L_4 refer to the first, second—fourth quadrants of high and low pressure areas. H→L stands for the region between isobars 759.5 and 764.5 when the high-pressure area follows the low-pressure area, L→H is bounded by the same isobars but the low pressure follows the high, $C_H \rightarrow C_L$ is the region between the centers of low and high pressure, and $C_L \rightarrow C_H$ is the region between the centers of high and low pressure. The arrows indicate the order of motion of these centers. Figures 14 to 22 also show the relation existing between wind direction at the 1-kilometer level and the different types of surface air pressure. It is probable that in a flat country, wind directions at the 1-kilometer level would be less characteristic of the prevailing type of surface air pressure than those of some lower level. It is thought that, in the vicinity of Mount Weather, the influence of topography on the directions of surface and low level winds masks somewhat their relations to the prevailing type of surface air pressure.

The west and north components of the observed air movement at the different levels have been considered. Table XXV shows the former; Table XXVI the latter. The means for the different seasons and for the year at all levels show that the west component of the air's movement increases rather steadily with altitude. The north component has a maximum value at the 2.5-kilometer level in the summer and autumn months, at the 1.5-kilometer level in the winter months, but a minimum value at the 1-kilometer level in the spring and at the 0.75-kilometer level in the year. On the whole this component varies little with altitude.

The value of the west component, also its rate of increase with altitude, is greatest in the winter and least in the summer months, all levels considered. It is less up to the 1.5-kilometer level but increases more rapidly with altitude in the spring than in the autumn months. The value of the north component varies but little from zero in the winter and spring months. For the upper levels in the winter months and the lower levels in the spring months this variation is negative. This component, though never large, is positive at all levels in the summer and in the autumn months. Its maximum value, at the 2.5 kilometer level in both seasons, is 4.3 meters per second in summer and 4.1 in autumn.

Considering the limitations of the method of observation, i. e., that observations could not be made daily, and that only two observations a few hours apart could be made on any one day, the information furnished by these wind data on the part taken by the lower 3 kilometers of the atmosphere over Mount Weather in the general atmospheric circulation can not be considered quantatively accurate. It is probable, however, that most of the general indications, above pointed out, are qualitatively correct.

When these components are considered for the different wind directions at the 1-kilometer level, such variations from the mean values are found as may be expected from the fact that whatever their direction all winds usually increase rapidly in velocity up to about the 1-kilometer level. Up to this level the west component decreases in value in easterly winds, increases rapidly in westerly winds, but in the mean shows about the same rate of increase with altitude as it shows at higher levels. Above this level the west component usually increases at about its mean rate for the season whatever the wind direction at the level. The value of the north component decreases in southerly winds and increases in northerly winds though the mean shows little variation with altitude up to the 1-kilometer level. The north component usually has a not very pronounced maximum value in northerly winds and minimum value in southerly winds at the 1 to 2 kilometer level; i. e., at the level of maximum frequency of

these winds. This information of the relation between surface air pressure and the air movement at different levels above the surface is fairly well founded, the distribution and number of the observations for this purpose being much better than for the study of the general atmospheric circulation in the levels explored. The upper winds are westerly whatever the surface air pressure because of the increasing value of the west component with altitude. The north component actually varies but little with altitude, and is only relatively smaller at the higher than at the lower levels.

The resultant values of these components and the number of observations considered, for each group and level, are shown in Table XXVII.

TABLE I.—*Monthly mean of free-air temperatures, July 1, 1907, to June 30, 1912.*

Altitude above sea level, meters.	January.			February.			March.			April.			May.			June.		
	Observations.	Temperature.	Δt per 100 m.	Observations.	Temperature.	Δ per 100 m.	Observations.	Temperature.	Δt per 100 m.	Observations.	Temperature.	Δ per 100 m.	Observations.	Temperature.	Δt per 100 m.	Observations.	Temperature.	Δt per 100 m.
		° C.	° C.		° C.	° C.		° C.	° C.		° C.	° C.		° C.	° C.		° C.	° C.
526	139	− 1.3	......	128	− 0.8	......	142	4.6	......	139	10.4	......	142	17.0	......	134	19.7	......
750	139	− 1.7	0.16	128	− 1.6	0.32	142	3.5	0.44	139	8.8	0.64	142	15.2	0.72	134	18.2	0.60
1,000	135	− 2.0	0.12	122	− 2.4	0.32	137	2.5	0.40	134	7.4	0.56	137	13.4	0.72	132	16.7	0.60
1,250	131	− 2.5	0.20	119	− 2.9	0.20	133	1.6	0.36	126	6.1	0.52	130	11.6	0.72	121	15.2	0.60
1,500	120	− 2.9	0.16	114	− 3.4	0.20	129	0.7	0.36	122	4.6	0.60	119	9.9	0.68	113	13.7	0.60
1,750	112	− 3.4	0.20	101	− 4.1	0.28	119	− 0.3	0.40	117	3.1	0.60	107	8.3	0.64	102	12.3	0.56
2,000	101	− 4.0	0.24	89	− 4.8	0.28	116	− 1.3	0.40	109	1.7	0.56	95	6.6	0.68	89	10.8	0.60
2,250	91	− 4.7	0.28	79	− 5.6	0.32	107	− 2.4	0.44	97	0.4	0.52	84	5.0	0.64	73	9.4	0.56
2,500	79	− 5.7	0.40	61	− 6.8	0.48	95	− 3.6	0.48	85	− 0.9	0.52	75	3.5	0.60	62	8.0	0.56
2,750	68	− 6.8	0.44	53	− 7.8	0.40	78	− 4.9	0.52	74	− 2.2	0.52	67	2.0	0.60	55	6.6	0.56
3,000	56	− 8.2	0.56	48	− 9.0	0.48	67	− 6.2	0.52	65	− 3.6	0.56	57	0.5	0.60	53	5.1	0.60
3,250	41	− 9.6	0.56	38	−10.5	0.60	58	− 7.6	0.56	53	− 5.1	0.60	49	− 1.0	0.60	49	3.5	0.64
3,500	32	−10.9	0.52	30	−12.0	0.60	41	− 8.9	0.52	47	− 6.7	0.64	42	− 2.6	0.64	36	1.9	0.64
3,750	22	−12.2	0.52	21	−13.3	0.52	31	−10.3	0.56	41	− 8.2	0.60	33	− 4.1	0.60	30	0.3	0.64
4,000	21	−13.6	0.56	16	−14.8	0.60	21	−11.8	0.60	39	− 9.7	0.60	27	− 5.7	0.64	20	− 1.5	0.72
4,250	16	−15.0	0.56	9	−16.3	0.60	15	−13.5	0.68	22	−11.4	0.68	21	− 7.3	0.64	15	− 3.3	0.72
4,500	10	−16.4	0.56	7	−17.7	0.56	13	−15.1	0.64	16	−13.0	0.64	16	− 9.1	0.68	10	− 4.9	0.64
4,750	6	−18.0	0.64	2	−19.9	0.88	9	−16.6	0.60	8	−14.5	0.60	11	−11.1	0.80	10	− 6.3	0.56
5,000	5	−19.4	0.56	1	−21.1	0.48	8	−18.1	0.60	6	−16.0	0.60	5	−13.1	0.80	8	− 7.7	0.56
5,250	2	−20.8	0.56	1	−22.9	0.72	2	−19.5	0.56	5	−17.6	0.64	2	−15.0	0.76	7	− 9.1	0.56
5,500	2	−22.4	0.64	......	......	......	......	......	......	5	−19.3	0.68	1	−16.5	0.60	5	−10.6	0.60
5,750	1	−25.3	1.16	......	......	......	......	......	......	3	−20.9	0.64	1	−18.0	0.60	......	......	......
6,000	......	......	......	......	......	......	......	......	......	2	−22.7	0.72	1	−19.5	0.60	......	......	......
6,250	......	......	......	......	......	......	......	......	......	2	−24.5	0.72	1	−21.0	0.60	......	......	......
6,500	......	......	......	......	......	......	......	......	......	2	−26.2	0.68	1	−22.4	0.56	......	......	......
6,750	......	......	......	......	......	......	......	......	......	2	−27.9	0.68	1	−23.8	0.56	......	......	......
7,000	......	......	......	......	......	......	......	......	......	1	−29.3	0.56	1	−25.1	0.52	......	......	......
7,250	......	......	......	......	......	......	......	......	......	......	......	......	1	−26.4	0.52	......	......	......

Altitude above sea level, meters.	July.			August.			September.			October.			November.			December.		
	Observations.	Temperature.	Δt per 100 m.	Observations.	Temperature.	Δt per 100 m.	Observations.	Temperature.	Δt per 100 m.	Observations.	Temperature.	Δt per 100 m.	Observations.	Temperature.	Δt per 100 m.	Observations.	Temperature.	Δt per 100 m.
		° C.	° C.		° C.	° C.		° C.	° C.		° C.	° C.		° C.	° C.		° C.	° C.
526	145	22.8		146	21.5		141	19.0		146	11.7		139	5.1		141	−0.3	
750	145	21.1	0.68	146	19.9	0.64	141	17.5	0.60	146	10.3	0.56	139	3.9	0.48	141	−1.2	0.36
1,000	142	19.3	0.72	143	18.3	0.64	137	16.1	0.56	143	9.0	0.52	138	2.8	0.44	138	−1.9	0.28
1,250	137	17.6	0.68	138	16.8	0.60	130	14.8	0.52	135	8.0	0.40	132	1.7	0.44	134	−2.3	0.16
1,500	129	15.9	0.68	127	15.3	0.60	124	13.5	0.52	126	7.1	0.36	122	0.7	0.40	122	−2.6	0.12
1,750	111	14.3	0.64	114	13.9	0.56	107	12.5	0.40	114	6.3	0.32	111	−0.2	0.36	114	−3.0	0.16
2,000	97	12.7	0.64	104	12.5	0.56	98	11.4	0.44	105	5.5	0.32	104	−0.9	0.28	99	−3.7	0.28
2,250	76	11.2	0.60	75	11.2	0.52	73	10.3	0.44	96	4.6	0.36	89	−1.8	0.36	89	−4.6	0.36
2,500	61	9.7	0.60	58	9.8	0.56	54	9.0	0.52	86	3.5	0.44	80	−2.9	0.44	82	−5.6	0.40
2,750	43	8.3	0.56	42	8.4	0.56	45	7.6	0.56	70	2.3	0.48	66	−4.2	0.52	67	−6.8	0.48
3,000	38	6.8	0.60	33	6.8	0.64	40	6.2	0.56	60	1.0	0.52	58	−5.5	0.52	56	−8.1	0.52
3,250	31	5.1	0.68	28	5.2	0.64	32	4.6	0.64	50	−0.4	0.56	47	−6.8	0.52	45	−9.5	0.56
3,500	27	3.5	0.64	21	3.8	0.56	30	3.1	0.60	40	−1.9	0.60	39	−8.3	0.60	32	−10.9	0.56
3,750	25	1.8	0.68	17	2.3	0.60	20	1.5	0.64	36	−3.4	0.60	32	−9.9	0.64	21	−12.3	0.56
4,000	21	0.1	0.68	15	0.7	0.64	14	−0.2	0.68	30	−4.7	0.52	27	−11.4	0.60	14	−13.6	0.52
4,250	16	−1.6	0.68	10	−0.9	0.64	10	−1.9	0.68	25	−6.1	0.56	20	−12.9	0.60	10	−15.1	0.60
4,500	10	−3.2	0.64	7	−2.7	0.72	8	−3.7	0.72	21	−7.5	0.56	17	−14.5	0.64	8	−16.7	0.64
4,750	6	−4.8	0.64	2	−4.8	0.84	3	−5.8	0.84	16	−9.1	0.64	12	−16.1	0.64	5	−18.2	0.60
5,000	5	−6.3	0.60	2	−6.8	0.80	2	−6.6	0.32	10	−10.9	0.72	10	−17.5	0.56	3	−19.4	0.48
5,250	5	−7.7	0.56	1	−9.0	0.88	2	−7.2	0.24	8	−12.7	0.72	8	−18.7	0.48			
5,500	2	−9.1	0.56	1	−11.2	0.88	1	−8.1	0.36	7	−14.1	0.56	6	−20.1	0.56			
5,750	1	−10.6	0.60	1	−13.6	0.96	1	−8.9	0.32	4	−15.6	0.60	1	−21.5	0.56			
6,000	1	−12.1	0.60	1	−16.2	1.04	1	−11.1	0.88	3	−17.2	0.64	1	−23.0	0.60			
6,250	1	−13.6	0.60				1	−13.6	1.00	1	−18.0	0.32						
6,500	1	−15.0	0.56				1	−16.7	1.24	1	−20.9	1.16						
6,750	1	−16.5	0.60				1	−20.2	1.40	1	−23.2	0.92						
7,000	1	−17.9	0.56							1	−26.0	1.12						
7,250																		

TABLE II.—*Seasonal and annual mean free air temperatures—July 1, 1907 to June 30, 1912.*

Altitude above sea level, meters.	Spring.			Summer.			Autumn.			Winter.			Annual.		
	Observations.	Temperature.	*Δt* per 100 m.	Observations.	Temperature.	*Δt* per 100 m.	Observations.	Temperature.	*Δt* per 100 m.	Observations.	Temperature.	*Δt* per 100 m.	Observations.	Temperature.	*Δt* per 100 m.
		° *C.*	° *C.*		° *C.*	° *C.*		° *C.*	° *C.*		° *C.*	° *C.*		° *C.*	° *C.*
526	423	10.7		425	21.4		426	12.0		408	−0.8		1,682	10.9	
750	423	9.2	0.60	425	19.8	0.64	426	10.7	0.52	408	−1.5	0.28	1,682	9.6	0.52
1,000	408	7.8	0.56	417	18.2	0.64	418	9.4	0.52	395	−2.1	0.24	1,638	8.4	0.48
1,250	389	6.5	0.52	396	16.6	0.64	397	8.3	0.44	384	−2.6	0.20	1,566	7.3	0.44
1,500	370	5.2	0.52	369	15.1	0.60	372	7.3	0.40	356	−3.0	0.16	1,467	6.2	0.44
1,750	343	3.9	0.52	327	13.6	0.60	332	6.4	0.36	327	−3.5	0.20	1,329	5.1	0.44
2,000	320	2.6	0.52	290	12.1	0.60	307	5.6	0.32	289	−4.2	0.28	1,206	4.0	0.44
2,250	288	1.3	0.52	224	10.7	0.56	258	4.6	0.40	259	−5.0	0.32	1,029	2.9	0.44
2,500	255	0.0	0.52	181	9.3	0.56	220	3.5	0.44	222	−6.0	0.40	878	1.7	0.48
2,750	219	−1.4	0.56	140	7.9	0.56	181	2.2	0.52	188	−7.1	0.44	728	0.4	0.52
3,000	189	−2.8	0.56	124	6.4	0.60	158	0.9	0.52	160	−8.4	0.52	631	−1.0	0.56
3,250	160	−4.3	0.60	108	4.8	0.64	129	−0.5	0.56	124	−9.8	0.56	521	−2.5	0.60
3,500	130	−5.8	0.60	84	3.2	0.64	109	−2.0	0.60	94	−11.2	0.56	417	−4.0	0.60
3,750	105	−7.3	0.60	72	1.6	0.64	88	−3.5	0.60	64	−12.5	0.52	329	−5.5	0.60
4,000	87	−8.8	0.60	56	−0.1	0.68	71	−5.0	0.60	51	−13.9	0.56	265	−7.0	0.60
4,250	58	−10.4	0.64	41	−1.8	0.68	55	−6.5	0.60	35	−15.3	0.56	189	−8.6	0.64
4,500	45	−12.1	0.68	27	−3.4	0.64	46	−8.1	0.64	25	−16.8	0.60	143	−10.2	0.64
4,750	28	−13.8	0.68	18	−4.9	0.60	31	−9.7	0.64	13	−18.4	0.64	90	−11.8	0.64
5,000	19	−15.5	0.68	15	−6.4	0.60	22	−11.2	0.60	9	−19.7	0.52	65	−13.3	0.60
5,250	9	−17.1	0.64	13	−7.9	0.60	18	−12.6	0.56	3	−21.3	0.64	43	−14.8	0.60
5,500	6	−18.8	0.68	8	−9.5	0.64	14	−14.0	0.56	2	−22.9	0.64	30	−16.3	0.60
5,750	4	−20.4	0.64	2	−11.5	0.80	6	−15.4	0.56	1	−25.8	1.16	13	−18.0	0.68
6,000	3	−22.1	0.68	2	−13.5	0.80	5	−17.1	0.68				10	−19.8	0.72
6,250	3	−23.8	0.68	1	−15.0	0.60	2	−18.7	0.64				6	−21.4	0.64
6,500	3	−25.4	0.64	1	−16.4	0.56	2	−21.7	1.20				6	−23.4	0.80
6,750	3	−27.0	0.64	1	−17.9	0.60	2	−24.6	1.16				6	−25.4	0.80
7,000	2	−28.4	0.56	1	−19.3	0.56	1	−27.4	1.12				4	−27.1	0.68
7,250	1	−29.7	0.52										1	−28.4	0.52

TABLE III.—*Miscellaneous Mount Weather data related to the temperature data in Table I, July 1, 1907 to June 30, 1912.*

		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	Mean surface temperatures	−1.4	−1.2	4.1	9.9	15.9	19.1	22.0	20.5	18.0	[1] 11.6	8.4	−0.4
2	Corrected mean surface temperatures	−2.3	−1.6	1.5	8.3	15.5	20.1	22.2	21.1	17.2	11.8	4.5	−0.2
3	Mean surface temperatures, kite observations	−1.3	−0.8	4.6	10.4	17.0	19.7	22.8	21.5	19.0	11.7	5.1	−0.3
4	Reductions, line 1 minus line 3	−0.1	−0.4	−0.5	−0.5	−1.1	−0.6	−0.8	−1.0	−1.0	−0.1	−0.3	−0.1
5	Reductions, line 2 minus line 3	−1.0	−0.8	−3.1	−2.1	−1.5	+0.4	−0.6	−0.4	−1.8	+0.1	−0.6	+0.1
6	Per cent of kite observations in a. m.	67	68	62	58	57	54	58	54	55	64	66	73
7	Mean time of a. m. kite observations	10.20	10.20	10.10	9.50	9.45	9.50	9.40	9.35	10.05	10.20	10.20	10.20
8	Per cent of kite observations in p. m.	33	32	38	42	43	46	42	46	45	36	34	27
9	Mean time of p. m. kite observations	3.25	3.25	3.50	3.05	3.40	3.30	3.30	3.25	3.25	3.20	3.10	3.55
10	Mean duration of actual sunshine, in hours	144	165	212	222	296	257	*317	*255	*244	*224	161	141
11	Mean cloudiness, per cent	60	59	54	58	51	56	*48	*54	*48	*43	55	58
12	Mean surface wind velocity, m. p. s.	8.3	8.8	8.4	7.8	6.3	5.3	*5.0	*4.9	*5.2	*6.6	*8.8	*8.6
	Mean wind directions:												
13	At surface	N. 88° W.	N. 69° W.	S. 84° W.	S. 66° W.	S. 89° W.	N. 83° W.	N. 88° W.	S. 42° W.	S. 47° W.	N. 72° W.	N. 84° W.	N. 75° W.
14	At 1,000 meters	S. 85° W.	S. 86° W.	S. 78° W.	S. 64° W.	S. 68° W.	N. 77° W.	N. 80° W.	S. 80° W.	S. 88° W.	N. 80° W.	N. 87° W.	N. 79° W.
15	At 2,000 meters	W.	N. 85° W.	S. 89° W.	S. 80° W.	S. 86° W.	N. 68° W.	N. 76° W.	N. 79° W.	N. 65° W.	N. 67° W.	N. 79° W.	N. 79° W.
16	At 3,000 meters	S. 85° W.	N. 84° W.	N. 84° W.	S. 88° W.	N. 89° W.	N. 68° W.	N. 68° W.	N. 74° W.	N. 64° W.	N. 62° W.	N. 88° W.	N. 80° W.
17	At 4,000 meters	S. 85° W.	S. 83° W.	N. 78° W.	W.	N. 75° W.	N. 70° W.	N. 73° W.	N. 83° W.	N. 75° W.	N. 74° W.	S. 87° W.	N. 86° W.

* No record in 1907.

TABLE IV.—*Mean free air temperatures in highs, by quadrants and seasons—July 1, 1907 to June 30, 1912.*

Altitude above sea level, meters.	I. Spring. Observations.	I. Spring. Temperature.	I. Spring. Δt per 100 m.	I. Summer. Observations.	I. Summer. Temperature.	I. Summer. Δt per 100 m.	I. Autumn. Observations.	I. Autumn. Temperature.	I. Autumn. Δt per 100 m.	I. Winter. Observations.	I. Winter. Temperature.	I. Winter. Δt per 100 m.
		° C.	° C.		° C.	° C.		° C.	° C.		° C.	° C.
526	30	4.6	.....	14	18.1	.....	42	8.2	.....	63	− 3.4	.....
750	30	2.5	0.84	14	16.7	0.56	42	6.5	0.68	63	− 4.7	0.52
1,000	29	0.6	0.76	14	15.3	0.56	42	5.0	0.60	62	− 5.7	0.40
1,250	27	− 0.8	0.56	13	14.0	0.52	41	3.8	0.48	61	− 5.9	0.08
1,500	27	− 1.9	0.44	12	13.0	0.40	37	3.1	0.28	57	− 6.2	0.12
1,750	26	− 2.9	0.40	11	11.7	0.52	36	2.3	0.32	55	− 6.3	0.04
2,000	26	− 3.7	0.32	9	10.5	0.48	35	1.9	0.16	45	− 6.7	0.16
2,250	25	− 4.6	0.36	8	9.2	0.52	29	1.2	0.28	41	− 7.3	0.24
2,500	24	− 6.3	0.68	7	8.2	0.40	29	0.2	0.40	35	− 8.3	0.40
2,750	21	− 7.5	0.48	6	7.2	0.40	25	− 1.0	0.48	30	− 9.1	0.32
3,000	19	− 8.8	0.52	5	5.9	0.52	24	− 2.2	0.48	25	−10.2	0.44
3,250	16	−10.2	0.56	5	4.6	0.52	20	− 3.4	0.48	17	−11.6	0.56
3,500	14	−11.7	0.60	3	3.5	0.44	17	− 4.6	0.48	13	−13.0	0.56
3,750	13	−12.9	0.48	3	2.7	0.32	14	− 5.8	0.48	10	−14.3	0.52
4,000	11	−14.3	0.56	2	1.3	0.56	11	− 7.1	0.52	6	−15.5	0.48
4,250	8	−15.9	0.64	2	− 0.1	0.56	10	− 8.5	0.56	3	−17.3	0.72
4,500	5	−17.8	0.76	2	− 1.7	0.64	9	−10.0	0.60	3	−19.2	0.76
4,750	4	−19.6	0.72	2	− 3.4	0.68	6	−11.6	0.64	1	−21.2	0.80
5,000	3	−21.1	0.60	2	− 5.1	0.68	4	−13.1	0.60	1	−23.1	0.76
5,250	3	−22.6	0.60	2	− 7.0	0.76	3	−14.5	0.56			
5,500	3	−24.2	0.64	1	− 8.9	0.76	3	−15.9	0.56			
5,750	2	−25.7	0.60									
6,000	1	−27.2	0.60									
6,250	1	−28.7	0.60									
6,500	1	−30.1	0.56									
6,750	1	−31.5	0.56									
7,000	1	−32.8	0.52									
7,250	1	−34.1	0.52									

Altitude above sea level, meters.	II. Spring. Observations.	II. Spring. Temperature.	II. Spring. Δt per 100 m.	II. Summer. Observations.	II. Summer. Temperature.	II. Summer. Δt per 100 m.	II. Autumn. Observations.	II. Autumn. Temperature.	II. Autumn. Δt per 100 m.	II. Winter. Observations.	II. Winter. Temperature.	II. Winter. Δt per 100 m.
		° C.	° C.		° C.	° C.		° C.	° C.		° C.	° C.
526	18	9.4	.....	10	23.0	.....	31	13.0	.....	43	− 1.1	.....
750	18	8.7	0.28	10	21.4	0.64	31	12.1	0.36	43	− 1.3	0.08
1,000	18	7.6	0.44	10	19.3	0.84	30	11.4	0.28	43	− 1.1	−0.08
1,250	17	7.0	0.24	10	17.9	0.56	28	10.6	0.32	42	− 1.1	0.00
1,500	17	5.9	0.44	9	16.2	0.68	27	9.4	0.48	40	− 1.2	0.04
1,750	15	4.4	0.60	7	14.6	0.64	24	8.1	0.52	38	− 1.5	0.12
2,000	14	3.0	0.56	7	13.2	0.56	23	6.9	0.48	36	− 2.4	0.36
2,250	14	1.8	0.48	4	11.9	0.52	19	5.5	0.56	32	− 3.3	0.36
2,500	12	0.4	0.56	4	10.5	0.56	17	4.0	0.60	29	− 4.3	0.40
2,750	12	− 0.7	0.44	2	9.5	0.40	14	2.9	0.44	27	− 5.3	0.40
3,000	8	− 2.1	0.56				14	1.7	0.48	23	− 6.6	0.52
3,250	7	− 3.4	0.52				13	0.3	0.56	20	− 7.9	0.52
3,500	7	− 4.9	0.60				11	− 1.1	0.56	15	− 9.3	0.56
3,750	5	− 6.2	0.52				9	− 2.6	0.60	10	−10.6	0.52
4,000	3	− 7.5	0.52				9	− 4.0	0.56	6	−12.0	0.56
4,250	2	− 8.7	0.48				8	− 5.6	0.64	5	−13.3	0.52
4,500	2	− 9.9	0.48				7	− 7.1	0.60	5	−14.7	0.56
4,750	1	−11.4	0.60				6	− 8.5	0.56	4	−16.3	0.64
5,000							6	− 9.8	0.52	4	−17.6	0.52
5,250							6	−11.1	0.52	3	−19.2	0.64
5,500							5	−12.5	0.56	2	−20.8	0.64
5,750							2	−13.9	0.56	1	−22.2	0.56
6,000							2	−15.4	0.60			
6,250							1	−16.2	0.32			
6,500							1	−19.1	1.16			
6,750							1	−21.4	0.92			
7,000							1	−24.2	1.12			
7,250												

TABLE IV.—*Mean free air temperatures in highs, by quadrants and seasons—July 1, 1907 to June 30, 1912.*

III.

Altitude above sea level, meters.	Spring. Observations.	Spring. Temperature.	Spring. Δt per 100 m.	Summer. Observations.	Summer. Temperature.	Summer. Δt per 100 m.	Autumn. Observations.	Autumn. Temperature.	Autumn. Δt per 100 m.	Winter. Observations.	Winter. Temperature	Winter. Δt per 100 m.
		°C.	°C.		°C.	°C.		°C.	°C.		°C.	°C.
526	40	8.1		36	20.3		51	12.9		37	−3.8	
750	40	6.8	0.52	36	18.6	0.68	51	11.9	0.40	37	−3.7	−0.04
1,000	37	5.7	0.44	34	16.7	0.76	49	11.2	0.28	35	−3.1	−0.24
1,250	34	5.2	0.20	32	15.2	0.60	46	10.5	0.28	33	−2.0	−0.44
1,500	30	4.8	0.16	27	13.8	0.56	39	9.9	0.24	31	−1.1	−0.36
1,750	26	4.1	0.28	21	12.6	0.48	30	9.4	0.20	28	−0.6	−0.20
2,000	23	3.1	0.40	18	11.5	0.44	28	8.4	0.40	26	−1.0	0.16
2,250	18	2.2	0.36	12	10.4	0.44	23	7.5	0.36	24	−1.8	0.32
2,500	15	1.4	0.32	12	9.3	0.44	15	6.2	0.52	22	−2.4	0.24
2,750	13	0.4	0.40	6	8.0	0.52	11	4.8	0.56	19	−3.6	0.48
3,000	10	−0.8	0.48	4	6.8	0.48	9	3.5	0.52	16	−5.1	0.60
3,250	7	−2.2	0.56	2	5.8	0.40	8	2.0	0.60	13	−6.6	0.60
3,500	3	−3.5	0.52	1	4.6	0.48	7	0.3	0.68	10	−8.1	0.60
3,750	3	−5.1	0.64	1	3.4	0.48	7	−1.3	0.64	9	−9.5	0.56
4,000	3	−6.9	0.72	1	2.3	0.44	7	−2.7	0.56	8	−10.9	0.56
4,250	3	−8.6	0.68				6	−4.5	0.72	7	−12.2	0.52
4,500	1	−9.7	0.44				5	−6.4	0.76	5	−13.3	0.44
4,750	1	−10.9	0.48				3	−8.5	0.84	3	−14.7	0.56
5,000	1	−12.1	0.48				2	−9.3	0.32	2	−15.7	0.40
5,250	1	−13.5	0.56				2	−9.9	0.24			
5,500	1	−14.9	0.56				1	−10.8	0.36			
5,750	1	−16.4	0.60				1	−11.6	0.32			
6,000	1	−18.1	0.68				1	−13.8	0.88			
6,250	1	−20.0	0.76				1	−16.3	1.00			
6,500	1	−21.7	0.68				1	−19.4	1.24			
6,750	1	−23.5	0.72				1	−22.9	1.40			

IV.

Altitude above sea level, meters.	Spring. Observations.	Spring. Temperature.	Spring. Δt per 100 m.	Summer. Observations.	Summer. Temperature.	Summer. Δt per 100 m.	Autumn. Observations.	Autumn. Temperature.	Autumn. Δt per 100 m.	Winter. Observations.	Winter. Temperature.	Winter. Δt per 100 m.
		°C.	°C.		°C.	°C.		°C.	°C.		°C.	°C.
526	43	5.8		33	18.9		52	10.8		38	−3.2	
750	43	3.8	0.80	33	17.2	0.68	52	9.1	0.68	38	−4.6	0.56
1,000	40	2.0	0.72	33	15.6	0.64	52	7.7	0.56	37	−5.7	0.44
1,250	38	0.7	0.52	31	14.3	0.52	47	6.9	0.32	35	−5.8	0.04
1,500	37	−0.2	0.36	25	13.0	0.52	46	6.4	0.20	32	−5.9	0.04
1,750	34	−1.0	0.32	23	12.0	0.40	40	6.4	0.00	30	−5.9	0.00
2,000	33	−1.9	0.36	21	10.9	0.44	36	6.1	0.12	28	−6.0	0.04
2,250	31	−2.9	0.40	14	9.7	0.48	30	5.4	0.28	24	−6.5	0.20
2,500	27	−3.8	0.36	11	8.4	0.52	27	4.2	0.48	24	−7.6	0.44
2,750	25	−4.8	0.40	5	6.9	0.60	22	3.1	0.44	21	−8.9	0.52
3,000	22	−6.0	0.48	4	5.2	0.68	18	1.7	0.56	20	−10.2	0.52
3,250	16	−7.2	0.48	4	3.6	0.64	13	0.3	0.56	14	−11.4	0.48
3,500	11	−8.5	0.52	2	2.4	0.48	11	−0.9	0.48	10	−12.6	0.48
3,750	9	−9.8	0.52	2	1.4	0.40	7	−2.4	0.60	9	−13.8	0.48
4,000	8	−11.1	0.52				6	−4.0	0.64	8	−15.1	0.52
4,250	6	−12.7	0.64				5	−5.6	0.64	6	−16.7	0.64
4,500	5	−14.3	0.64				5	−7.2	0.64	2	−20.3	1.44
4,750	3	−16.2	0.76				2	−8.0	0.32	1	−22.3	0.80
5,000	1	−17.8	0.64				1	−9.5	0.60	1	−24.2	0.76
5,250							1	−11.0	0.60			
5,500							1	−12.4	0.56			
5,750							1	−13.8	0.56			
6,000							1	−15.3	0.60			
6,250												
6,500												
6,750												

TABLE V.—*Mean free air temperatures in front and rear of highs, by seasons—July 1, 1907 to June 30, 1912.*

Altitude above sea level, meters.	Front.												Rear.											
	Spring.			Summer.			Autumn.			Winter.			Spring.			Summer.			Autumn.			Winter.		
	Observations.	Temperature.	Δt per 100 m.	Observations.	Temperature.	Δt per 100 m.	Observations.	Temperature.	Δt per 100 m	Observations.	Temperature.	Δt per 100 m.	Observations.	Temperature.	Δt per 100 m.	Observations.	Temperature.	Δt per 100 m.	Observations.	Temperature.	Δt per 100 m.	Observations.	Temperature.	Δt per 100 m.
		°C.	°C.		°C.	°C.		°C.	°C.		°C.	°C.		°C.	°C.		°C.	°C.		°C.	°C.		°C.	°C.
526...	73	5.3	......	47	18.7	......	94	9.6	......	101	−3.3	......	58	8.5	......	46	20.9	......	82	12.9	......	80	−2.3	......
750...	73	3.2	0.84	47	17.1	0.64	94	7.9	0.68	101	−4.6	0.52	58	7.4	0.44	46	19.2	0.68	82	12.0	0.36	80	−2.4	0.04
1,000...	69	1.4	0.72	47	15.5	0.64	94	6.4	0 60	99	−5.6	0.40	55	6.3	0.44	44	17.3	0.76	79	11.3	0.28	78	−2.0	−0.16
1,250...	65	0.1	0.52	44	14.2	0.52	88	5.4	0.40	96	−5.7	0.04	51	5.8	0.20	42	15.8	0.60	74	10.6	0.28	75	−1.5	−0.20
1,500...	64	−0.9	0.40	37	13.0	0.48	83	4.8	0.24	89	−5.9	0.08	47	5.1	0.28	36	14.3	0 60	66	9.8	0.32	71	−1.2	−0.12
1,750...	60	−1.8	0.36	34	11.9	0.44	76	4.4	0.16	85	−6.0	0.04	41	4.1	0.40	28	13.0	0.52	54	9.0	0.32	66	−1.2	0.00
2,000...	59	−2.6	0.32	30	10.7	0.48	71	4.1	0.12	73	−6.3	0.12	37	3.0	0.44	25	11.8	0.48	51	7.9	0.44	62	−1.9	0.28
2,250...	56	−3.6	0.40	22	9.5	0.48	59	3.4	0.28	65	−6.9	0.24	32	2.0	0.40	16	10.6	0.48	42	6.8	0.44	56	−2.8	0.36
2,500...	51	−4.7	0.44	18	8.3	0.48	56	2.3	0.44	59	−7.9	0.40	27	0.9	0.44	16	9.4	0.48	32	5.4	0.56	51	−3.6	0.32
2,750...	46	−5.8	0.44	11	7.1	0.48	47	1.1	0.48	51	−8.9	0.40	25	−0.2	0.44	8	8.2	0.48	25	4.2	0.48	46	−4.7	0.44
3,000...	41	−7.0	0.48	9	5.6	0.60	42	−0.2	0.52	45	−10.1	0.48	18	−1.5	0.52	4	7.0	0.48	23	3.0	0.48	39	−6.1	0.56
3,250...	32	−8.3	0.52	9	4.2	0.56	33	−1.5	0.52	31	−11.4	0.52	14	−2.9	0.56	2	6.0	0.40	21	1.6	0.56	33	−7.5	0.56
3,500...	25	−9.7	0.56	5	3.1	0.44	28	−2.7	0.48	23	−12.7	0.52	10	−4.3	0.56	1	4.8	0.48	18	0.1	0.60	25	−9.0	0.60
3,750...	22	−11.0	0.52	5	2.2	0.36	21	−4.0	0.52	19	−14.0	0.52	8	−5.7	0.56	1	3.6	0.48	16	−1.5	0.64	19	−10.4	0.56
4,000...	19	−12.3	0.52	2	0.8	0.56	17	−5.4	0.56	14	−15.3	0.52	6	−7.3	0.64	1	2.5	0.44	16	−2.9	0.56	14	−11.8	0.56
4,250...	14	−13.9	0.64	2	−0.6	0.56	15	−6.9	0 60	9	−17.0	0.68	5	−8.8	0.60	......	......	......	14	−4.6	0.68	12	−13.1	0.52
4,500...	10	−15.6	0.68	2	−2.2	0.64	14	−8.4	0.60	5	−19.5	1.00	3	−10.0	0.48	......	......	......	12	−6.3	0.68	10	−14.3	0.48
4,750...	7	−17.4	0.72	2	−3.9	0.68	8	−9.8	0.56	2	−21.5	0.80	2	−11.4	0.56	......	......	......	9	−7.9	0.64	7	−15.8	0.60
5,000...	4	−18.9	0.60	2	−5.6	0.68	5	−11.3	0.60	2	−23.4	0.76	1	−12.6	0.48	......	......	......	8	−9.1	0.48	6	−17.0	0.48
5,250...	3	−20.4	0.60	2	−7.5	0.76	4	−12.7	0.56	......	......	......	1	−14.0	0.56	......	......	......	8	−10.2	0.44	3	−18.6	0.64
5,500...	3	−22.0	0.64	1	−9.4	0.76	4	−14.1	0.56	......	......	......	1	−15.4	0.56	......	......	......	6	−11.5	0.52	2	−20.2	0.64
5,750...	2	−23.5	0.60	......	......	......	1	−15.5	0.56	......	......	......	1	−16.9	0.60	......	......	......	3	−12.7	0.48	1	−21.6	0.56
6,000...	1	−25.0	0.60	......	......	......	1	−17.0	0.60	......	......	......	1	−18.6	0.68	......	......	......	3	−14.4	0.68	......	......	......
6,250...	1	−26.5	0.60	......	......	......	......	......	......	......	......	......	1	−20.5	0.76	......	......	......	2	−16.0	0.64	......	......	......
6,500...	1	−27.9	0.56	......	......	......	......	......	......	......	......	......	1	−22.2	0.68	......	......	......	2	−19.0	1.20	......	......	......
6,750...	1	−29.3	0.56	......	......	......	......	......	......	......	......	......	1	−24.0	0.72	......	......	......	2	−21.9	1.16	......	......	......
7,000...	1	−30.6	0.52	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	−24.7	1.12	......	......	......
7,250...	1	−31.9	0.52	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......

TABLE VI.—*Mean free air temperatures in lows, by quadrants and seasons—July 1, 1907 to June 30, 1912.*

I.

Altitude above sea level, meters.	Spring. Observations.	Spring. Temperature.	Spring. Δt per 100 m.	Summer. Observations.	Summer. Temperature.	Summer. Δt per 100 m.	Autumn. Observations.	Autumn. Temperature.	Autumn. Δt per 100 m.	Winter. Observations.	Winter. Temperature.	Winter. Δt per 100 m.
		°C.	°C.		°C.	°C.		°C.	°C.		°C.	°C.
526	9	9.6		2	22.8		3	4.7		6	− 0.4	
750	9	8.9	0.28	2	20.6	0.88	3	4.5	0.08	6	− 1.6	0.48
1,000	9	8.9	0.00	2	19.9	0.28	3	4.3	0.08	5	− 1.3	−0.12
1,250	8	8.4	0.20	2	18.4	0.60	2	4.9	−0.24	5	0.3	−0.64
1,500	7	6.8	0.64	2	17.2	0.48	2	5.0	−0.04	4	0.7	−0.16
1,750	5	5.6	0.48	2	15.8	0.56	1	4.2	0.32	4	− 0.3	0.40
2,000	4	4.5	0.44	1	14.7	0.44	1	4.0	0.08	4	− 1.5	0.48
2,250	2	2.7	0.72				1	4.8	−0.32	3	− 2.9	0.56
2,500	2	1.4	0.52				1	3.4	0.56	2	− 4.1	0.48
2,750	1	− 0.1	0.60							2	− 5.7	0.64
3,000	1	− 2.0	0.76							2	− 7.4	0.68
3,250	1	− 4.2	0.88							2	− 8.4	0.40
3,500	1	− 6.3	0.84							1	−10.1	0.68
3,750	1	− 8.4	0.84									
4,000	1	−10.4	0.80									
4,250												
4,500												
4,750												
5,000												
5,250												
5,500												
5,750												
6,000												
6,250												
6,500												
6,750												
7,000												

II.

Altitude above sea level, meters.	Spring. Observations.	Spring. Temperature.	Spring. Δt per 100 m.	Summer. Observations.	Summer. Temperature.	Summer. Δt per 100 m.	Autumn. Observations.	Autumn. Temperature.	Autumn. Δt per 100 m.	Winter. Observations.	Winter. Temperature.	Winter. Δt per 100 m.
		°C.	°C.		°C.	°C.		°C.	°C.		°C.	°C.
526	16	8.2		18	20.6		14	6.9		17	− 1.6	
750	16	6.2	0.80	18	18.9	0.68	14	5.2	0.68	17	− 3.2	0.64
1,000	16	4.8	0.56	18	17.3	0.64	14	3.2	0.80	16	− 4.6	0.56
1,250	15	3.5	0.52	18	15.8	0.60	13	2.4	0.32	16	− 6.0	0.56
1,500	14	2.5	0.40	17	14.4	0.56	11	1.1	0.52	15	− 7.1	0.44
1,750	14	1.4	0.44	15	12.7	0.68	11	0.0	0.44	13	− 7.7	0.24
2,000	13	0.2	0.48	14	11.3	0.56	7	− 0.9	0.36	8	− 6.3	−0.56
2,250	12	− 1.3	0.60	14	10.0	0.52	7	− 1.7	0.32	7	− 6.4	0.04
2,500	9	− 2.4	0.44	13	8.4	0.64	6	− 2.6	0.36	7	− 7.2	0.32
2,750	7	− 3.6	0.48	13	6.8	0.64	4	− 4.1	0.60	4	− 8.7	0.60
3,000	7	− 4.5	0.36	13	5.2	0.64	4	− 5.6	0.60	2	− 9.9	0.48
3,250	7	− 5.6	0.44	13	3.6	0.64	4	− 7.1	0.60	2	−10.7	0.32
3,500	4	− 6.5	0.36	12	2.2	0.56	3	− 8.6	0.60	1	−11.8	0.44
3,750	3	− 7.9	0.56	8	0.6	0.64	3	−10.0	0.56	1	−12.9	0.44
4,000	2	− 9.4	0.60	8	− 1.1	0.68	3	−11.2	0.48	1	−14.1	0.48
4,250	2	−10.8	0.56	7	− 2.7	0.64	2	−12.0	0.32			
4,500	2	−12.4	0.64	6	− 4.0	0.52	1	−13.3	0.52			
4,750	1	−14.4	0.80	5	− 5.6	0.64	1	−14.6	0.52			
5,000	1	−16.3	0.76	5	− 7.2	0.64						
5,250				4	− 8.6	0.56						
5,500				2	−10.3	0.68						
5,750				2	−12.3	0.80						
6,000				2	−14.3	0.80						
6,250				1	−15.8	0.60						
6,500				1	−17.2	0.56						
6,750				1	−18.7	0.60						
7,000				1	−20.1	0.56						

TABLE VI.—*Mean free air temperatures in lows, by quadrants and seasons—July 1, 1907 to June 30, 1912.*

Altitude above sea level, meters.	III. Spring. Observations.	III. Spring. Temperature.	III. Spring. Δt per 100 m.	III. Summer. Observations.	III. Summer. Temperature.	III. Summer. Δt per 100 m.	III. Autumn. Observations.	III. Autumn. Temperature.	III. Autumn. Δt per 100m.	III. Winter. Observations.	III. Winter. Temperature.	III. Winter. Δt per 100 m.
		° C.	° C.		° C.	° C.		° C.	° C.		° C.	° C.
526...	56	11.8	......	46	20.9	......	36	9.8	......	46	2.3	......
750...	56	10.1	0.68	46	19.5	0.56	36	7.6	0.88	46	0.9	0.56
1,000...	56	8.5	0.64	46	18.0	0.60	35	5.5	0.84	46	− 0.8	0.68
1,250...	56	6.8	0.68	45	16.3	0.68	35	3.9	0.64	46	− 2.3	0.60
1,500...	56	5.2	0.64	44	14.6	0.68	34	2.3	0.64	45	− 3.4	0.44
1,750...	53	3.6	0.64	43	13.0	0.64	33	1.2	0.44	40	− 4.6	0.48
2,000...	49	2.2	0.56	40	11.5	0.60	32	0.2	0.40	36	− 5.7	0.44
2,250...	45	0.9	0.52	36	9.9	0.64	26	− 0.8	0.40	31	− 6.8	0.44
2,500...	40	− 0.5	0.56	34	8.5	0.56	22	− 1.9	0.44	26	− 8.0	0.48
2,750...	33	− 2.0	0.60	30	7.0	0.60	19	− 3.4	0.60	21	− 9.2	0.48
3,000...	30	− 3.4	0.56	30	5.8	0.48	14	− 4.6	0.48	13	−10.8	0.64
3,250...	25	− 4.9	0.60	25	4.4	0.56	13	− 5.8	0.48	9	−12.2	0.56
3,500...	18	− 6.4	0.60	20	2.9	0.60	9	− 7.5	0.68	9	−13.5	0.52
3,750...	14	− 7.8	0.56	18	1.3	0.64	9	− 9.4	0.76	6	−14.7	0.48
4,000...	13	− 9.3	0.60	15	− 0.3	0.64	6	−11.2	0.72	6	−15.9	0.48
4,250...	9	−11.0	0.68	13	− 1.9	0.64	3	−12.8	0.64	2	−16.9	0.40
4,500...	7	−12.8	0.72	8	− 3.6	0.68	3	−14.2	0.56	2	−18.3	0.56
4,750...	4	−14.6	0.72	4	− 5.3	0.68	2	−15.6	0.56	1	−19.2	0.36
5,000...	3	−16.2	0.64	3	− 6.9	0.64	1	−16.7	0.44	1	−20.0	0.32
5,250...	1	−18.4	0.88	2	− 8.5	0.64	1	−18.0	0.52	......	......	......
5,500...	......	......	......	1	−10.2	0.68	1	−19.3	0.52	......	......	......
5,750...	......	......	......	......	......	......	......	......	......	......	......	......

Altitude above sea level, meters.	IV. Spring. Observations.	IV. Spring. Temperature.	IV. Spring. Δt per 100 m.	IV. Summer. Observations.	IV. Summer. Temperature.	IV. Summer. Δt per 100 m.	IV. Autumn. Observations.	IV. Autumn. Temperature.	IV. Autumn. Δt per 100 m.	IV. Winter. Observations.	IV. Winter. Temperature.	IV. Winter. Δt per 100 m.
		° C.	° C.		° C.	° C.		° C.	° C.		° C.	° C.
526...	32	12.5	......	9	20.5	......	19	15.0	......	16	2.5	......
750...	32	11.6	0.36	9	19.2	0.52	19	14.1	0.36	16	3.3	−0.32
1,000...	32	10.8	0.32	9	17.8	0.56	19	12.8	0.52	16	3.1	0.08
1,250...	32	9.6	0.48	7	16.2	0.64	18	11.3	0.60	15	2.3	0.32
1,500...	30	8.2	0.56	7	14.7	0.60	16	9.9	0.56	15	1.3	0.40
1,750...	29	6.6	0.64	6	13.1	0.64	13	8.7	0.48	15	0.3	0.40
2,000...	26	5.1	0.60	6	11.5	0.64	11	7.7	0.40	14	− 1.1	0.56
2,250...	22	3.6	0.60	5	10.0	0.60	10	6.6	0.44	12	− 2.1	0.40
2,500...	20	1.8	0.72	3	8.5	0.60	6	5.8	0.32	6	− 3.3	0.48
2,750...	18	0.0	0.72	3	7.4	0.44	6	4.4	0.56	5	− 5.1	0.72
3,000...	18	− 1.6	0.64	3	5.6	0.72	5	3.1	0.52	5	− 6.5	0.56
3,250...	14	− 3.1	0.60	3	3.8	0.72	4	1.5	0.64	4	− 7.8	0.52
3,500...	12	− 4.5	0.56	3	1.8	0.80	4	0.0	0.60	3	− 8.8	0.40
3,750...	6	− 6.1	0.64	2	0.0	0.72	2	− 1.8	0.72	2	−10.2	0.56
4,000...	4	− 7.5	0.56	1	− 2.1	0.84	2	− 3.6	0.72	2	−11.8	0.64
4,250...	......	......	......	1	− 3.6	0.60	1	− 5.1	0.60	2	−13.4	0.64
4,500...	......	......	......	......	......	......	1	− 6.7	0.64	......	......	......
4,750...	......	......	......	......	......	......	1	− 8.3	0.64	......	......	......
5,000...	......	......	......	......	......	......	1	−10.0	0.68	......	......	......
5,250...	......	......	......	......	......	......	1	−11.9	0.76	......	......	......
5,500...	......	......	......	......	......	......	1	−13.3	0.56	......	......	......
5,750...	......	......	......	......	......	......	1	−14.6	0.52	......	......	......

TABLE VII.—*Mean free air temperatures, in front and rear of lows, by seasons—July 1, 1907 to June 30, 1912.*

FRONT.

Altitude above sea level, meters.	Spring. Observations.	Spring. Temperature.	Spring. Δt per 100 m.	Summer. Observations.	Summer. Temperature.	Summer. Δt per 100 m.	Autumn. Observations.	Autumn. Temperature.	Autumn. Δt per 100 m.	Winter. Observations.	Winter. Temperature.	Winter. Δt per 100 m.
		° C.	° C.		° C.	° C.		° C.	° C.		° C.	° C.
526...	41	11.9	...	11	20.9	...	22	13.6	...	22	1.7	...
750...	41	11.0	0.36	11	19.5	0.56	22	12.8	0.32	22	2.0	−0.12
1,000...	41	10.4	0.24	11	18.2	0.52	22	11.7	0.44	21	2.0	0.00
1,250...	40	9.4	0.40	9	16.6	0.64	20	10.4	0.52	20	1.8	0.08
1,500...	37	7.9	0.60	9	15.2	0.56	18	9.2	0.48	19	1.1	0.28
1,750...	34	6.4	0.60	8	13.6	0.64	14	8.0	0.48	19	0.1	0.40
2,000...	30	4.9	0.60	7	12.1	0.60	12	7.0	0.40	18	− 1.2	0.52
2,250...	24	3.4	0.60	5	10.6	0.60	11	6.1	0.36	15	− 2.3	0.44
2,500...	22	1.7	0.68	3	9.1	0.60	7	5.3	0.32	8	− 3.5	0.48
2,750...	19	− 0.1	0.72	3	8.0	0.44	6	3.9	0.56	7	− 5.2	0.68
3,000...	19	− 1.7	0.64	3	6.2	0.72	5	2.6	0.52	7	− 6.7	0.60
3,250...	15	− 3.3	0.64	3	4.4	0.72	4	1.0	0.64	6	− 7.9	0.48
3,500...	13	− 4.8	0.60	3	2.4	0.80	4	− 0.5	0.60	4	− 9.1	0.48
3,750...	7	− 6.4	0.64	2	0.6	0.72	2	− 2.3	0.72	2	−10.5	0.56
4,000...	5	− 7.9	0.60	1	− 1.5	0.84	2	− 4.1	0.72	2	−12.1	0.64
4,250...	...	...	...	1	− 3.0	0.60	1	− 5.6	0.60	2	−13.7	0.64
4,500...	...	...	...	...	...	...	1	− 7.2	0.64	...	...	...
4,750...	...	...	...	...	...	...	1	− 8.8	0.64	...	...	...
5,000...	...	...	...	...	...	...	1	−10.5	0.68	...	...	...
5,250...	...	...	...	...	...	...	1	−12.4	0.76	...	...	...
5,500...	...	...	...	...	...	...	1	−13.8	0.56	...	...	...
5,750...	...	...	...	...	...	...	1	−15.1	0.52	...	...	...
6,000...	...	...	...	...	...	...	...	...	...	...	...	...
6,250...	...	...	...	...	...	...	...	...	...	...	...	...
6,500...	...	...	...	...	...	...	...	...	...	...	...	...
6,750...	...	...	...	...	...	...	...	...	...	...	...	...
7,000...	...	...	...	...	...	...	...	...	...	...	...	...

REAR.

Altitude above sea level, meters.	Spring. Observations.	Spring. Temperature.	Spring. Δt per 100 m.	Summer. Observations.	Summer. Temperature.	Summer. Δt per 100 m.	Autumn. Observations.	Autumn. Temperature.	Autumn. Δ per 100 m.	Winter. Observations.	Winter. Temperature.	Winter. Δ per 100 m.
		° C.	° C.		° C.	° C.		° C.	° C.		° C.	° C.
526...	72	11.0	...	64	20.8	...	50	9.0	...	63	1.2	...
750...	72	9.2	0.72	64	19.3	0.60	50	7.0	0.80	63	− 0.3	0.60
1,000...	72	7.6	0.64	64	17.8	0.60	49	5.0	0.80	62	− 1.9	0.64
1,250...	71	6.0	0.64	63	16.2	0.64	48	3.6	0.56	62	− 3.4	0.60
1,500...	70	4.5	0.60	61	14.6	0.64	45	2.1	0.60	60	− 4.5	0.44
1,750...	67	3.0	0.60	58	13.0	0.64	44	1.0	0.44	53	− 5.6	0.44
2,000...	62	1.6	0.56	54	11.5	0.60	39	0.0	0.40	44	− 6.2	0.24
2,250...	57	0.3	0.52	50	10.0	0.60	33	− 1.0	0.40	38	− 7.1	0.36
2,500...	49	− 1.0	0.52	47	8.5	0.60	28	− 2.0	0.40	33	− 8.2	0.44
2,750...	40	− 2.5	0.60	43	7.0	0.60	23	− 3.5	0.60	25	− 9.5	0.52
3,000...	37	− 3.8	0.52	43	5.6	0.56	18	− 4.8	0.52	15	−11.0	0.60
3,250...	32	− 5.2	0.56	38	4.2	0.56	17	− 6.0	0.48	11	−12.3	0.52
3,500...	22	− 6.6	0.56	32	2.7	0.60	12	− 7.7	0.68	10	−13.6	0.52
3,750...	17	− 7.9	0.52	26	1.1	0.64	12	− 9.4	0.68	7	−14.8	0.48
4,000...	15	− 9.4	0.60	23	− 0.5	0.64	9	−11.0	0.64	7	−16.0	0.48
4,250...	11	−11.0	0.64	20	− 2.1	0.64	5	−12.3	0.52	2	−17.0	0.40
4,500...	9	−12.8	0.72	14	− 3.6	0.60	4	−13.7	0.56	2	−18.4	0.56
4,750...	5	−14.6	0.72	9	− 5.3	0.68	3	−15.1	0.56	1	−19.3	0.36
5,000...	4	−16.3	0.68	8	− 6.9	0.64	1	−16.2	0.44	1	−20.1	0.32
5,250...	1	−18.5	0.88	6	− 8.3	0.56	1	−17.5	0.52	...	...	...
5,500...	...	...	...	3	−10.0	0.68	1	−18.8	0.52	...	...	...
5,750...	...	...	...	2	−12.0	0.80	...	...	...	...	...	...
6,000...	...	...	...	2	−14.0	0.80	...	...	...	...	...	...
6,250...	...	...	...	1	−15.5	0.60	...	...	...	...	...	...
6,500...	...	...	...	1	−16.9	0.56	...	...	...	...	...	...
6,750...	...	...	...	1	−18.4	0.60	...	...	...	...	...	...
7,000...	...	...	...	1	−19.8	0.56	...	...	...	...	...	...

TABLE VIII.—*Mean free air temperatures between highs and lows, by seasons—July 1, 1907 to June 30, 1912.*

Altitude above sea level, meters.	Low NW., W., or SW.; high NE., E., or SE.												Low NE. or E.; high NW., W., or SW.					
	Spring.			Summer.			Autumn.			Winter.			Spring.			Summer.		
	Observa-tions.	Temper-ature.	Δt per 100 m.	Observa-tions.	Temper-ature.	Δt per 100 m.	Observa-tions.	Temper-ature.	Δt per 100 m.	Observa-tions.	Temper-ature.	Δt per 100 m.	Observa-tions.	Temper-ature.	Δt per 100 m.	Observa-tions.	Temper-ature.	Δt per 100 m.
		° C.	° C.		° C.	° C.		° C.	° C.		° C.	° C.		° C.	° C.		° C.	° C.
526	89	14.6		94	22.5		59	15.0		42	2.6		62	11.8		119	22.0	
750	89	13.5	0.44	94	20.8	0.68	59	14.3	0.28	42	2.0	0.24	62	9.8	0.80	119	20.4	0.64
1,000	84	12.3	0.48	91	19.1	0.68	59	13.5	0.32	40	2.4	−0.16	61	7.8	0.80	118	18.8	0.64
1,250	79	10.8	0.60	83	17.5	0.64	57	12.3	0.48	40	1.5	0.36	59	6.1	0.68	116	17.2	0.64
1,500	74	9.2	0.64	77	15.8	0.68	53	11.0	0.52	37	0.6	0.36	57	4.5	0.64	113	15.7	0.60
1,750	65	7.6	0.64	69	14.1	0.68	47	9.7	0.52	35	− 0.5	0.44	54	3.1	0.56	102	14.3	0.56
2,000	62	5.9	0.68	57	12.5	0.64	43	8.4	0.52	34	− 1.6	0.44	54	1.6	0.60	92	12.8	0.60
2,250	51	4.2	0.68	38	11.0	0.60	38	7.0	0.56	29	− 2.7	0.44	51	0.3	0.52	74	11.4	0.56
2,500	45	2.5	0.68	26	9.4	0.64	34	5.6	0.56	27	− 4.0	0.52	46	− 0.9	0.48	57	9.9	0.60
2,750	40	1.0	0.60	19	7.9	0.60	30	4.1	0.60	22	− 5.0	0.40	39	− 2.1	0.48	45	8.3	0.64
3,000	31	− 0.5	0.60	15	6.3	0.64	27	2.7	0.56	21	− 6.4	0.56	33	− 3.5	0.56	42	6.6	0.68
3,250	28	− 2.2	0.68	11	4.6	0.68	21	1.1	0.64	19	− 7.9	0.60	32	− 5.1	0.64	37	5.0	0.64
3,500	24	− 3.9	0.68	7	2.9	0.68	17	− 0.6	0.68	14	− 9.4	0.60	27	− 6.7	0.64	31	3.4	0.64
3,750	21	− 5.6	0.68	6	1.2	0.68	13	− 2.3	0.68	8	−10.6	0.48	23	− 8.3	0.64	27	1.8	0.64
4,000	18	− 7.2	0.64	5	− 0.7	0.76	11	− 3.8	0.60	7	−11.9	0.52	17	−10.0	0.68	19	0.2	0.64
4,250	12	− 8.8	0.64	2	− 2.9	0.88	8	− 5.2	0.56	6	−13.2	0.52	11	−11.7	0.68	13	−1.6	0.72
4,500	10	−10.3	0.60				5	− 7.0	0.72	3	−14.3	0.44	9	−13.5	0.72	10	−3.2	0.64
4,750	6	−11.6	0.52				5	− 9.0	0.80				6	−15.2	0.68	7	−4.4	0.48
5,000	5	−13.1	0.60				2	−10.7	0.68				4	−17.0	0.72	5	−5.6	0.48
5,250	3	−14.7	0.64				1	−11.7	0.40				1	−18.5	0.60	5	−7.0	0.56
5,500	2	−16.7	0.80													3	−8.8	0.72
5,750	1	−18.6	0.76															
6,000	1	−20.5	0.76															
6,250	1	−22.2	0.68															
6,500	1	−23.9	0.68															
6,750	1	−25.5	0.64															
7,000	1	−26.9	0.56															

Altitude above sea level, meters.	Low NE. or E.; high NW., W., or SW.						Low moving up Atlantic coast; high N.											
	Autumn.			Winter.			Spring.			Summer.			Autumn.			Winter.		
	Observa-tions.	Temper-ature.	Δt per 100 m.	Observa-tions.	Temper-ature.	Δt per 100 m.	Observa-tions.	Temper-ature.	Δt per 100 m.	Observa-tions.	Temper-ature.	Δt per 100 m.	Observa-tions.	Temper-ature.	Δt per 100 m.	Observa-tions.	Temper-ature.	Δt per 100 m.
		° C.	° C.		° C.	° C.		° C.	° C.		° C.	° C.		° C.	° C.		° C.	° C.
526	62	11.6		63	−1.2		12	8.0		32	21.8		22	15.2		5	−4.2	
750	62	10.0	0.64	63	−3.0	0.72	12	6.4	0.64	32	20.3	0.60	22	13.4	0.72	5	−2.8	−0.56
1,000	61	8.5	0.60	63	−4.5	0.60	11	5.0	0.56	31	18.9	0.56	22	12.0	0.56	3	−3.8	0.40
1,250	61	7.0	0.60	61	−5.6	0.44	10	4.4	0.24	26	17.3	0.64	20	10.9	0.44	3	−5.7	0.76
1,500	58	5.6	0.56	57	−6.2	0.24	9	3.6	0.32	25	15.7	0.64	20	9.7	0.48	2	−6.7	0.40
1,750	53	4.4	0.48	50	−7.1	0.36	9	2.9	0.28	20	14.1	0.64	20	8.5	0.48	2	−6.9	0.08
2,000	49	3.5	0.36	42	−7.6	0.20	6	1.9	0.40	19	12.7	0.56	19	7.3	0.48	1	−8.1	0.48
2,250	42	2.7	0.32	39	−8.1	0.20	6	0.3	0.64	14	11.3	0.56	17	6.3	0.40	1	−9.3	0.48
2,500	38	1.7	0.40	33	−8.9	0.32	6	−1.1	0.56	12	9.7	0.64	12	5.3	0.40			
2,750	31	0.4	0.52	26	−9.9	0.40	4	−2.7	0.64	9	8.2	0.60	10	4.3	0.40			
3,000	28	−1.0	0.56	20	−11.2	0.52	3	−4.1	0.56	7	6.8	0.56	8	3.3	0.40			
3,250	23	−2.4	0.56	17	−12.9	0.68	3	−5.8	0.68	6	5.3	0.60	7	2.0	0.52			
3,500	22	−4.0	0.64	14	−14.4	0.60	3	−6.8	0.40	4	3.7	0.64	6	0.6	0.56			
3,750	19	−5.5	0.60	8	−16.1	0.68	2	−7.4	0.24	3	2.1	0.64	3	−0.8	0.56			
4,000	14	−6.8	0.52	6	−18.0	0.76	2	−7.6	0.08	3	0.3	0.72	2	−2.2	0.56			
4,250	10	−8.2	0.56	4	−19.8	0.72	2	−9.0	0.56	1	−1.5	0.72	1	−2.8	0.24			
4,500	8	−9.7	0.60	3	−21.9	0.84	1	−9.8	0.32	1	−3.6	0.84	1	−4.4	0.64			
4,750	4	−11.6	0.76	2	−24.0	0.84							1	−5.9	0.60			
5,000	3	−14.1	1.00										1	−7.3	0.56			
5,250	2	−16.4	0.92										1	−8.8	0.60			
5,500	1	−18.2	0.72										1	−10.2	0.56			
5,750	1	−20.1	0.76															
6,000	1	−21.8	0.68															

TABLE IX.—*Low NW., W., or SW.; high NE., E., or SE. of Mount Weather.*

Date.	Wind velocity at surface.	Wind direction at— Surface 526 m.	1,000 m.	2,000 m.	3,000 m.	4,000 m.	Turning CW. or CCW.*	Clouds. Am't.	Kind.	Dir.	Remarks.
1910.	*m.p.s.*										
July 6	6	sse.	s.	......	......	......	CW.	4 6	Ci. St.-Cu.	nw. w.	
July 12	5	sse.	ssw.	sw.	......	......	CW.	3 1 1	A.-Cu. St.-Cu. St.	wsw. wsw. sse.	
July 21	8	s.	s.	......	......	......	......	Few.	Cu.	ssw.	
July 24	5	sw.	sw.	sw.	sw.	......	......	Few.	Cu.	ssw.	
Aug. 1	4	s.	s.	sw.	wsw.	......	CW.	2 3	Ci.-Cu. Cu.	w. wsw.	
ug. 2	2	ese.[1]	se.[1]	w.	w.	......	CW.	8 1	A.-St. Cu.	wnw. wnw.	
Aug. 3	7	s.	s.	ssw.	sw.	......	CW.	6	Cu.	s.	
Aug. 10	6	s.	sw.	sw.	sw.	sw.	CW.	5 5 Light.	A.-St. St.-Cu. Fog.	sw. sw. s.	Light rain.
Aug. 20	5	se.	sse.	w.	w.	......	CW.	2	St.-Cu.	nw.	
Aug. 21	7	sse.	s.	sw.	......	......	CW	1 8	A.-St. St.-Cu.	sw. ssw.	
Aug. 22	6	s.	s.	ssw.	......	......	CW.	8 Few.	A.-St. Cu.	sw. sw.	
Aug. 23	5	ssw.	s.	......	......	......	CCW.	0	......	......	Dense haze.
Aug. 23	6	sse.	s.	ssw.	......	......	CW.	1	Cu.	sw.	Light haze.
Aug. 25	7	s.	sw.	wsw.	wsw.	wsw.	CW.	2 3 5	Ci.-Cu. St.-Cu. St.	w. w. s.	
Sept. 5	5	ssw.	wsw.	w.	wnw.	wnw.	CW.	8	A.-Cu.	w.	Light rain.
Sept. 8	2	se.[1]	Calm	sw.	......	......	CW.	0	......	......	Light haze.
Sept. 25	7	sse.	ssw.	......	......	......	CW.	3 3 2	St.-Cu. Cu. St.	sw. s. s.	
Sept. 26	0	Calm.	Calm	Calm	Calm	......	......	4	Cu.	wsw.	
Sept. 27	3	s.	sw.	sw.	sw.	......	CW.	2 2 2	Ci.-St. Ci.-Cu. Cu.	sw. sw. sw.	
Oct. 6	8	s.	ssw.	sw.	sw.	sw.	CW.	10 Dense.	St. Fog.	ssw. s.	
Oct. 6	8	s.	ssw.	sw.	sw.	sw.	CW.	3	St.	ssw.	
Oct. 18	7	se.	se.	sse.	......	......	CW.	2	St.-Cu.	s.	
Oct. 19	6	e.	se.	......	......	......	CW.	10	St.	se.	
Oct. 21	9	se.	sse.	sw.	sw.	......	CW.	10	St.	sse.	
Oct. 24	4	sse.	s.	w.	wsw.	......	CW.	Few. 3 3	A.-St. A.-Cu. St.-Cu.	sw. sw. sw.	
Nov. 2	6	sw.[1]	wsw.	sw.	sw.	sw.[2]	......	9	A.-St.	sw.	
Nov. 9	7	s.	sw.	w.	w.	w.	CW.	5	A.-Cu.	w.	
Nov. 21	6	s.	wsw.	......	......	......	CW.	1	St.-Cu.	wsw.	
Nov. 21	8	sse.	sw.	wsw.	wsw.	......	CW.	10	A.-St.	wsw.	
Nov. 23	10	se.	ssw.	sw.	wsw.	wsw.	CW.	6	A.-Cu.	w.	
Dec. 18	6	sse.	ssw.	sw.	sw.	......	CW.	6	A.-St.	sw.	
Dec. 28	10	s.	sw.	sw.	sw.	sw.	CW.	3 3 4	Ci.-St. A.-St. St.-Cu.	w. wnw. wsw.	
1911.											
Jan. 2	11	s.	sw.	sw.	sw.	......	CW.	10	St.-Cu.	s.	Light rain.
Feb. 14	10	ese.	s.	sw.	wsw.	......	CW.	5 5	Ci.-St. St.-Cu.	wnw. wsw.	Solar halo; light rain.
Feb. 26	7	s.	sw.	sw.	wsw.	wsw.	CW.	3 3 Few.	Ci.-St. A.-Cu. St.-Cu.	wsw. wsw. wsw.	
Mar. 12	9	se.	wsw.	w.	w.	w.[3]	CW.	5 5	Ci.-St. A.-St.	w. w.	
Apr. 6	6	wsw.[1]	wsw.	wsw.	......	......	......	4 4	A.-St. A.-Cu.	wsw. wsw.	
Apr. 6	9	sse.	s.	ssw.	sw.	wsw.	CW.	5 3 2	Ci.-St. A.-St. A.-Cu.	wnw. wnw. w.	
Apr. 21	3	ese.	Calm	nw.	......	......	CW.	7 Few.	Ci.-St. Ci.-Cu.	w. 0	
May 10	5	se.	s.	wsw.	......	......	CW.	5	St.-Cu.	wsw.	
May 12	5	s.	ssw.	sw.	wsw.	......	CW.	2 7	St. Cu.	w. sw.	

* CW. and CCW. represent clockwise and counter-clockwise, respectively.

[1] Variable. [2] SW. at 5,000 m. [3] W. at 5,000 m.

TABLE IX.—*Low NW., W., or SW.; high NE., E., or SE. of Mount Weather*—Contd.

Date.	Wind velocity at surface.	Wind direction at—					Turning CW. or CCW.*	Clouds.			Remarks.
		Surface 526 m.	1,000 m.	2,000 m.	3,000 m.	4,000 m.		Am't.	Kind.	Dir.	
1911.	*m.p.s.*										
May 19...	3	ese.[1]	Calm	wnw.	w.	......	CW.	Few.	Cu.	wnw.	Light haze.
May 20...	3	ese.	wsw.	sw.	......	......	CW.	0	....	......	Light haze.
May 21...	3	ese.	Calm	ssw.	......	......	CW.	0	....	......	Light haze.
May 22...	5	sse.	sse.	se.	......	......	CCW.	3	Cu.	se.	
May 23...	3	se.	se.	se.	......	......	....	6 1	Ci.-St. Cu.	wsw. sw.	
May 29...	4	se.	se.	ene.	......	......	CCW.	2 Few.	A.-St. St.-Cu.	nnw. se.	
June 4....	7	se.	sse.	ssw.	......	......	CW.	2 6	Ci.-Cu. St.-Cu.	nw. nw.	Light rain.
June 25...	5	se.	sse.	ssw.	sw.	......	CW.	1 8	A.-St. St.	wsw. se.	
June 26...	2	e.[1]	w.	wsw.	......	......	CW.	7	St. Cu.	wsw.	

* CW. and CCW. represent clockwise and counter-clockwise, respectively.

[1] Variable.

TABLE X.—*Low NE. or E.; high NW., W., or SW., of Mount Weather.*

Date.	Wind velocity at surface.	Wind direction at— Surface 526 m.	1,000 m.	2,000 m.	3,000 m.	4,000 m.	Turning CW. or CCW.*	Clouds. Amt.	Kind.	Dir.	Remarks.
1910.	*m.p.s.*										
July 9	2	w.	wsw.	wsw.	......	......	CCW.	6	Cu.	wsw.	
July 10	6	wnw.	nw.	......	......	......	CW.	3	A.-St.	wsw.	
July 11	8	nw.	nw.	nw.	nw.	......	......	4	St.-Cu.	nw.	
July 13	7	wnw.	wnw.	wnw.	w.	w.	CCW.	8 4	A.-St. St.-Cu.	wsw. w.	
July 15	4	nw.	nw.	......	......	......	......	9 Few.	Ci.-Cu. Cu.	w. w	
July 22	6	w.	wnw.	wsw.	......	......	CCW.	Few.	Ci.-St.	w.	
July 23	9	w.	wnw.	w.	wsw.	......	CCW.	5 4	Ci.-St. A.-Cu.	w. w.	Solar halo.
July 25	8	w.	w.	w.	w.	w.	......	2 2	Ci. A.-Cu.	w. w.	
July 31	6	nw.	nnw.	nw.	nw.	nw.	......	Few.	Cu.	nw.	
Aug. 6	8	w.	w.	wnw.	wnw.	w.[2]	......	3 6 Few.	Ci.-St. A.-St. Cu.	w. w. w.	
Aug. 7	2	nw.	sw.	wnw.	......	......	CCW.	4	Ci.-Cu.	w.	
Aug. 9	3	ese.	nw.	nw.	......	......	CCW.	Few.	Cu.	nw.	
Aug. 11	6	nw.	nw.	nw.	......	......	......	Few.	St.-Cu.	nw.	
Aug. 19	7	nw.	nnw.	nnw.	......	......	CW.	5 5	Ci.-St. St.	nw. nnw.	Solar halo.
Aug. 26	8	nnw.[1]	wnw.[1]	w.	......	......	CCW.	5 5	St.-Cu. St.	wsw. w.	Light rain.
Aug. 26	12	nw.	w.	wsw.	wsw.	......	CCW.	10	St.-Cu.	wsw.	Light rain.
Sept. 4	4	s.	wsw.	wnw.	......	......	CW.	5 Few.	St.-Cu. Cu.	sw. sw.	
Sept. 6	6	wsw.	w.	w.	w.	w.[2]	CW.	3 2	Ci.-St. St.-Cu.	w. w.	
Sept. 18	6	wnw.	nw.	nnw.	......	......	CW.	4 1	Ci. A.-St.	nw. n.	Solar halo.
Sept. 21	3	n.	e.	nnw.	......	......	CCW.	6	St.-Cu.	w.	
Sept. 28	8	nw.	nnw.	nw.	wnw.	......	CCW.	1 5 4	A.-Cu. St.-Cu. St.	w. nw. nnw.	
Oct. 9	11	wnw.	nw.	nw.	nw.	......	CW.	Few. Few. Dense.	Ci.-Cu. Cu. Fog.	nw. nw. wnw.	
Oct. 11	4	wsw.	w.	......	......	......	CW.	0	......	......	
Oct. 12	11	wnw.	wnw.	wnw.	nw.	nw.[3]	......	0	......	......	Light haze.
Oct. 16	11	w.	wnw.	nw.	nw.	nw.[4]	CW.	1 6	Ci.-St. A.-Cu.	nw. nw.	
Oct. 23	12	wnw.	wnw.	nw.	nnw.	......	CW.	2 1	A.-St. Cu.	nw. nw.	
Nov. 5	16	wnw.	wnw.	......	......	......	......	4 4	Ci.-St. A.-St.	wnw. wnw.	
Nov. 7	7	wnw.	wnw.	wnw.	nw.	......	CW.	Few. Few.	Ci.-Cu. Cu.	wnw. nw.	
Nov. 16	13	wnw.	nw.	wnw.	wnw.	......	......	10	St.-Cu.	wnw.	
Nov. 17	19	nw.	nw.	nw.	......	......	......	2 6	Ci.-Cu. St.-Cu.	nw. nw.	
Nov. 18	6	wnw.	w.	w.	w.	w.	CCW.	4	St.-Cu.	nw.	
Nov. 22	11	nw.	nw.	nw.	......	......	......	1 1 Light.	A.-Cu. St. Fog.	nw. nw. nw.	Light snow.
Nov. 24	5	wnw.	wnw.	nw.	......	......	CW.	2	Ci.-St.	nw.	
Dec. 2	16	wnw.	nw.	nw.	nw.	......	CW.	4	St.-Cu.	nnw.	Light haze.
Dec. 4	2	w.	wnw.	......	......	......	CW.	10	St.-Cu.	wnw.	
Dec. 7	10	wnw.	wnw.	w.	w.	......	CCW.	4 4	Ci.-St. A.-St.	wsw. wsw.	Stationary clouds.
Dec. 11	20	wnw.	wnw.	wnw.	wnw.	......	......	10	St.-Cu.	wnw.	Light snow.
Dec. 21	18	nw.	nw.	nnw.	......	......	CW.	Few.	St.-Cu.	nw.	
1911.											
Jan. 14	6	wsw.	w.	w.	w.	w.	CW.	2 6	A.-St. St.-Cu.	w. w.	
Jan. 27	7	wsw.	wsw.	w.	w.	w.	CW.	5 5	Ci.-St. St.-Cu.	wnw. wnw.	Solar halo.
Feb. 10	18	wnw.	wnw.	wnw.	......	......	......	3	St.-Cu.	wnw.	
Feb. 18	10	nw.	nw.	wnw.	......	......	CCW.	9 Light.	St. Fog.	wnw. nw.	Light rain.
Feb. 19	14	nw.	nnw.	nw.	......	......	......	8 2	A.-Cu. St.-Cu.	wnw. wnw.	

* CW. and CCW. represent clockwise and counter clockwise, respectively.

[1] Variable. [2] w. at 5,000 m. [3] nw. at 5,000 m.; wnw. at 6,000 m. [4] nw. at 5,000 m.

TABLE X.—*Low NE. or E.; high NW., W., or SW., of Mount Weather*—Continued.

Date.	Wind velocity at surface.	Wind direction at— Surface 526 m.	1,000 m.	2,000 m.	3,000 m.	4,000 m.	Turning CW. or CCW.*	Clouds. Amt.	Kind.	Dir.	Remarks.
1911.	*m.p.s.*										
Feb. 22...	18	wnw.	wnw.	nw.	......	......	CW.	5	St.-Cu.	nw.	
Feb. 25...	7	w.	w.	wnw.	wnw.	w.	....	4	A.-Cu.	wnw.	
Mar. 3....	6	wsw.	wsw.	wnw.	wnw.	wnw.	CW.	Few.	St.-Cu.	w.	
Mar. 3....	8	wsw.	w.	w.	wnw.	wnw[5]	CW.	3 Few. 3	Ci. St.-Cu. Cu.	w. w. w.	Solar halo.
Mar. 3....	10	wsw.	w.	w.	w.	......	CW.	5 3	Ci.-St. Cu.	w. w.	
Mar. 6....	11	nw.	nw.	nw.	nw.	......	....	2 8 Dense.	A.-Cu. St. Fog.	wnw. nw. nw.	
Mar. 18...	8	nw.	w.	w.	......	......	CCW.	5 5	A.-St. St.-Cu.	wsw. w.	
Mar. 21...	13	wnw.	nw.	nw.	nw.	nw.	CW.	0	....	......	
Mar. 23...	17	nw.	nw.	nw.	nw.	......	....	8	St.-Cu.	nw.	
Apr. 1....	9	wnw.	wnw.	wnw.	wnw.	w.	CCW.	2	St.-Cu.	wnw.	
Apr. 15...	10	wnw.	wnw.	wnw.	wnw.	......	....	3 3 2	Ci. Ci.-Cu. St.-Cu.	w. w. wnw.	Solar halo.
Apr. 16...	14	nw.	nw.	wnw.	......	......	CCW.	3	Cu.	wnw.	
Apr. 17...	12	nw.	nw.	wnw.	wnw.	wnw.	CCW.	2	St.-Cu.	wnw.	
Apr. 29...	2	w.	calm.	calm.	......	......	....	6 2	A.-Cu. St.-Cu.	nw. nw.	
May 12...	6	w.	w.	......	......	......	....	3 2 2	Ci.-St. St.-Cu. Cu.	w. w. w.	
May 16...	8	wnw.	wnw.	wnw.	wnw.	w.[2]	CCW.	5 5	Ci.-St. A.-Cu.	w. w.	Solar halo.
May 17...	4	nw.	nw.	......	......	......	....	5	Ci.-St.	wnw.	Light haze.
May 18...	6	w.	wnw.	wnw.	wnw.	wnw.	CW.	3 2	A.-St. Cu.	nw. wnw.	
May 23...	9	nw.	w.	sw.	......	......	CCW.	8 Few.	A.-Cu. Cu.	wsw. sw.	
May 24...	4	wnw.[1]	wnw.	w.	w.	w.	CCW.	6 2	Cu. Cu.-Nb	w. w.	
May 25...	13	wnw.	nw.	nw.	nnw.	nnw[6]	CW.	1 1	A.-Cu. Cu.	nw. nw.	Light haze.
May 26...	5	se.	se.	......	......	......	....	2 2 2	A.-Cu. A.-St. St.-Cu.	nw. nw. nw.	
June 3....	2	wnw.	w.	w.	......	......	CCW.	4 4	Ci.-St. Ci.-Cu.	w. w.	Solar halo.
June 6....	3	n.[5]	wnw.	wnw.	......	......	CCW.	Dense.	Fog.	n.	Light rain.
June 9....	2	wnw.	nw.	nnw.	nw.	......	CCW.	2 Few.	Ci. Cu.	w. nw.	
June 10...	5	w.	nw.	nnw.	......	......	CW.	5	Cu.	nw.	
June 19...	4	se.	s.	w.	......	......	CW.	1 8	Ci. A.-Cu.	w. w.	
June 20...	8	wnw.	nw.	nw.	nnw.	nw.[4]	CW.	Few. 5	A.-St. Cu.	nw. nw.	
June 21...	7	wnw.	nw.	nnw.	nnw.	nnw[4]	CW.	2	Ci.	nw.	
June 22...	5	wnw.	nw.	nw.	nw.	nw.[7]	CW.	Few.	Ci.-Cu.	nw.	
June 23...	9	wnw.	nw.	nw.	nw.	nw.[7]	CW.	3 2	Ci.-St. Cu.	w. w.	
June 24...	5	wnw.	nw.	nw.	......	......	CW.	2 1	Ci.-St. A.-St.	nw. nw.	Light haze.
June 27...	4	wsw.[5]	wnw.	wnw.	......	......	CW.	5 2	Ci.-St. A.-Cu.	nw. nw.	
June 28...	8	wnw.	nw.	nw.	wnw.	......	....	4 4	Ci.-St. Cu.	w. nw.	
June 29...	7	nw.	nw.	nw.	nw.	......	....	Few.	St.-Cu.	wnw.	

* CW. and CCW. represent clockwise and counter clockwise, respectively.

[1] Variable.
[2] w. at 5,000 m.
[4] nw. at 5,000 m.
[5] wnw. at 5,000 m.
[6] nnw. at 5,000 m.
[7] nw at 5,000 and 6,000 m.

TABLE XI.—*Low moving up Atlantic coast; high N. of Mount Weather.*

Date.	Wind velocity at surface.	Wind direction at—					Turning CW. or CCW.*	Clouds.			Remarks.
		Surface 526 m.	1,000 m.	2,000 m.	3,000 m.	4,000 m.		Amt.	Kind.	Dir.	
1910.	*m.p.s.*										
July 18...	5	ene.	ne.	ne.	ne.	......	CCW.	8 10	St.-Cu. St.	w. w.	
Aug. 8....	6	nw.	nnw.	nnw.	nnw.	......	CW.	6 Dense.	St. Fog.	nw. nw.	Light rain.
Aug. 15...	6	e.	e.	......	......	......	....	Dense.	Fog.	e.	
Aug. 16...	3	ese.	ne.	nne.	......	......	CCW.	3 4	A.-St. Cu.	e. ne.	
Aug. 28...	6	ese.	ese.	......	......	......	....	5 5	St.-Cu. St.	ese. ese.	
Sept. 1....	7	nw.	nw.	nnw.	nnw.	nnw.	CW.	1 4 5	Ci.-Cu. St.-Cu. St.	w. nw. nw.	
Sept. 2....	2	e.	ene.	nw.	......	......	CCW.	10	St.	ene.	
Sept. 19...	3	nw.	nnw.	nnw.	......	......	CW.	10	St.-Cu.	nnw.	
Oct. 15...	7	wnw.	nw.	nw.	......	......	CW.	3 Few.	Ci.-St. Cu.	nw. nw.	
Oct. 17...	2	se.	n.	nnw.	......	......	CCW.	Few.	A.-St.	?	
Nov. 3....	11	nw.	nnw.	nnw.	nnw.	wsw.[1]	CCW.	7 3	A.-St. St.-Cu.	s. nnw.	
Nov. 26...	16	nw.	nw.	nnw.	nnw.	......	CW.	4	St.-Cu.	nnw.	
1911.											
Feb. 9....	1	n.	wnw.	......	......	......	CCW.	10 Light.	St. Fog.	wnw. n.	Light snow.
Apr. 22...	7	e.	e.	......	......	......	....	5 5 Dense.	St.-Cu. St. Fog.	wnw. e. e.	
May 8....	7	ne.	ene.	ene.	ene.	ene.	CW.	10	A.-St.	ene.	Light rain.
May 9....	10	wnw.	wnw.	n.	n.	n.[2]	CW.	10	A.-St.	nnw.	Light rain.
June 7....	4	e.	ese.	......	......	......	CW.	10 Dense.	St. Fog.	e. e.	

*CW. and CCW. represent clockwise and counter-clockwise, respectively.

[1] s. at 5,000 m. [2] n. at 5,000 m.

TABLE XII.—*Low NW., W., or SW.; high NE., E., or SE. of Mount Weather.*

Date.	Wind velocity at surface.	Wind direction at— Surface 526 m.	1,000 m.	2,000 m.	3,000 m.	4,000 m.	Turning CW. or CCW.*	Clouds. Amt.	Kind.	Dir.	Remarks.
1911.	*m.p.s.*										
July 5....	6	sse.	s.	s.	......	......	CW.	2	Cu.	s.	Light haze.
July 15...	2	se.[1]	Calm.	Calm.	......	......	....	4 4 2	Ci. Ci.-St. Cu.	w. sw. 0	
July 16...	3	se.	sse.	Calm.	......	......	CW.	2	Ci.	wsw.	
	7	sse.	sse.	s.	s.	......	CW.	4 4	Ci. Cu.	wsw. s.	
July 19...	6	sse.	s.	sw.	......	......	CW.	3 4	Ci.-St. A.-St.	w. w.	
July 31...	3	s.[1]	e.	n.	......	......	CCW.	5	Cu.	ne.	
Aug. 1....	8	se.	se.	sse.	......	......	CW.	6	St.	se.	
	7	se.	se.	s.	......	......	CW.	3 3	Cu. St.-Cu.	s. s.	
Aug. 2....	6	sse.	s.	ssw	......	......	CW.	2 2 3	Ci. A.-Cu. St.-Cu.	w. w. s.	
Aug. 3....	7	se.	sse.	s.	s.	......	CW.	2 2 2	Ci.-Cu. Cu. St.	nw. s. se.	
Aug. 4....	6	sse.	se.	ssw.	......	......	CW.	4 2 2	A.-St. Cu. St.-Cu.	se. sw. sw.	
Aug. 7....	7	ese.	sse.	......	......	......	CW.	1	Cu.	se.	
Aug. 8....	6	se.[1]	sw.	......	......	......	CW.	4 4 1	A.-Cu. St.-Cu. St.	wnw. wnw. s.	
Aug. 10...	5	s.[1]	Calm.	Calm.	......	......	....	Few.	Ci.	wnw.	
Aug. 11...	4	sw.[1]	wsw.	......	......	......	CW.	Few.	St.-Cu.	wsw.	
	4	wsw.	wsw.	......	......	......	....	Few.	St.-Cu.	wsw.	
Aug. 25...	4	se.	sw.	wsw.	......	......	CW.	6	St.-Cu.	wsw.	
Aug. 27...	6	se.	sse.	s.	s.	......	CW.	2 3	A.-Cu. Cu.	ssw. ssw.	
Aug. 28...	8	s.	ssw.	ssw.	ssw.	ssw.	CW.	3 4	Ci. St.-Cu.	wsw. ssw.	
Sept. 2...	4	se.	wsw.	......	......	......	CW.	0	....	......	
Sept. 5...	8	se.	s.	ssw.	......	......	CW.	3 3	A.-Cu. St.-Cu.	w. s.	
Sept. 7...	4	s.	sw.	ssw.	......	......	CW.	2 2	Ci.-St. Cu.	nw. s.	
Sept. 15...	5	sw.	wsw.	w.	w.	w.	CW.	5 5	A.-Cu. A.-St.	wnw. wnw.	Light rain.
Sept. 18...	5	ese.	wsw.	nw.	......	......	CW.	3 2	Ci. St.-Cu.	nw. se.	
Oct. 15...	3	e.[1]	wnw.	w.	......	......	CW.	8 Dense.	St. Fog.	w. e.	
Oct. 16...	4	se.	se.	se.	se.	......	....	3	Ci.	w.	
Oct. 20...	4	e.	sse.	s.	......	......	CW.	Dense.	Fog.	e.	
Oct. 21...	3	w.[1]	wsw.[1]	sse.	......	......	CCW.	10 Light.	St. Fog.	nw. w.	
Oct. 31...	6	s.	sw.	wsw.	wsw.	......	CW.	10	A.-St.	sw.	Light rain.
Nov. 17...	12	se.	s.	wsw.	wsw.	......	CW.	5 5	A.-Cu. A.-St.	wnw. wnw.	Light haze.
Nov. 20...	7	s.	sw.	w.	......	......	CW.	1 4	Ci. St.-Cu.	w. w.	
Dec. 12...	5	sse.	ssw.	ssw.	ssw.	ssw.	CW.	2 4 4	Ci.-St. A.-Cu. St.-Cu.	w. sw. ssw.	Solar halo.
Dec. 15...	4	ese.	n.	sw.	......	......	CW.	Dense.	Fog.	ese.	
Dec. 24...	6	s.	ssw.	......	......	......	CW.	10	St.	ssw.	
1912.											
Jan. 18...	8	ssw.	ssw.	sw.	sw.	sw.	CW.	3 7	Ci.-St. A.-St.	w. w.	Solar halo.
Feb. 19...	4	s.	sw.	......	......	......	CW.	6	Ci.-St.	w.	Solar halo.
Mar. 8....	5	se.	ssw.	......	......	......	CW.	Dense.	Fog.	se.	
Mar. 19...	8	se.	ssw.	sw.	wsw.	w.[2]	CW.	4 3	A.-Cu. St.-Cu.	w. wsw.	
Mar. 26...	10	sse.	sw.	wsw.	w.	wnw.	CW.	3 1	Ci.-St. St.-Cu.	w. sw.	
Mar. 28...	7	se.	s.	ssw.	ssw.	......	CW.	5 5	A.-St. St.-Cu.	ssw. ssw.	Light rain.
Apr. 6....	7	wsw.	wsw.	wsw.	sw.	......	CCW.	2	Ci.-St.	wnw.	
Apr. 11...	6	sse.	ssw.	wsw.	w.	wnw.[3]	CW.	0	....	......	

* CW. and CCW. represent clockwise and counter-clockwise, respectively.

[1] Variable. [2] w. at 5,000 m. [3] wnw. at 5,000 m.

TABLE XII.—*Low NW., W., or SW.; high NE., E., or SE. of Mount Weather*—Con.

Date.	Wind velocity at surface.	Wind direction at— Surface 526 m.	1,000 m.	2,000 m.	3,000 m.	4,000 m.	Turning CW. or CCW.*	Clouds. Amt.	Kind.	Dir.	Remarks.
1912.	*m.p.s.*										
Apr. 12...	6	s.	ssw.	sw.	wsw.	w.	CW.	8 2	St.-Cu. Cu.-Nb.	wsw. wsw.	Thunderstorm; light rain.
Apr. 13...	5	ese.	sse.	......	......	......	CW.	10 Light.	St. Fog.	ese. ese.	
Apr. 14...	7	sse.	s.	ssw.	......	......	CW.	Dense.	Fog.	sse.	
Apr. 15...	8	sse.	ssw.	sw.	wsw.	w.	CW.	2 3 Dense.	Ci.-St. St.-Cu. Fog.	wsw. wsw. sse.	
Apr. 21...	9	se.	s.	s.	......	......	CW.	Dense.	Fog.	se.	
Apr. 27...	6	ssw.	wsw.	wsw.	wsw.	wsw.	CW.	3 3 4	Ci.-St. A.-St. St.-Cu.	wsw. wsw. wsw.	Solar halo; light rain.
May 1....	9	sse.	sse.	ssw.	sw.	......	CW.	4	Ci.-St.	w.	
May 4....	7	e.	e.	......	......	......	......	3	Ci.	w.	Solar halo.
May 5....	8	sse.	ssw.	wsw.	......	......	CW.	3 3 3	Ci.-St. A.-Cu. St.-Cu.	w. w. w.	
May 6....	6	se.	sse.	s.	......	......	CW.	5 5	A.-Cu. St.-Cu.	wsw. wsw.	
May 11...	10	sse.	s.	ssw.	ssw.	sw.	CW.	6	Ci.-St.	sw.	Solar halo.
May 14...	5	s.	ssw.	sw.	sw.	......	CW.	10	A.-St.	sw.	
May 15...	8	se.	se.	......	......	......	......	10	St.-Cu.	se.	Light rain.
May 20...	6	s.	s.	ssw.	sw.	wsw.	CW.	Few. 2	A.-Cu. Cu.	w. w.	Thunderstorm.
May 22...	8	sse.	sse.	sse.	......	......	......	2 1	Ci.-St. Cu.	(?). se.	
May 23...	8	sse.	s.	......	......	......	CW.	10 Dense.	St. Fog.	sse. sse.	
May 27...	8	sse.	s.	ssw.	sw.	......	CW.	4	Ci.	w.	
June 2....	5	wsw.	wsw.	wsw.	wsw.	wsw.	......	5 3 2	Ci.-St. A.-Cu. Cu.	wsw. wsw. wsw.	
June 6....	9	s.	ssw.	sw.	sw.	sw.	CW.	2 4 3	Ci. A.-Cu. St.-Cu.	w. sw. sw.	Thunderstorm; light rain.
June 14...	10	ese.	sse.	s.	......	......	CW.	5 5	A.-St. St.-Cu.	wsw. s.	
June 15...	10	sse.	s.	......	......	......	CW.	Dense.	Fog.	sse.	Light rain.
June 25...	5	se.	se.	......	......	......	......	10	St.-Cu.	se.	Light rain.
June 27...	7	e.	ese.	ese.	......	......	CW.	5 5 Light.	St.-Cu. St. Fog.	ese. e. e.	

* CW. and CCW. represent clockwise and counter-clockwise, respectively.

TABLE XIII.—*Low NE. or E.; high NW., W., or SW., of Mount Weather.*

Date.	Wind velocity at surface.	Wind direction at— Surface 526 m.	1,000 m.	2,000 m.	3,000 m.	4,000 m.	Turning CW. or CCW.*	Clouds. Amt.	Kind.	Dir.	Remarks.
1911.	*m.p.s.*										
July 6....	4	w.	nw.	nnw.	......	......	CW.	Few.	A.-Cu.	e.	
July 11...	8	wnw.	nw.	wnw.	wnw.	......	....	3	A.-Cu.	wsw.	
July 12...	3	w.[1]	wnw.	nnw.	......	......	CW.	1 Few.	Ci.-St. Cu.	wnw. nw.	
July 14...	2	ese.[1]	nw.	nw.	......	......	CCW.	2 2	A.-Cu. Cu.	sw. ne.	
July 18...	6	nw.	nnw.	wnw.	......	......	CCW.	5	Ci.-St.	sw.	
July 20...	3	se.[1]	s.	wnw.	......	......	CW.	4	A.-Cu.	wnw.	
July 25...	11	wnw.	wnw.	wnw.	wnw.	w.[2]	CCW.	Few. Few.	Ci.-Cu. Cu.	w. w.	
July 26...	2	w.[1]	Calm.	wsw.	......	......	CCW.	7	Cu.	sw.	
July 29...	4	wsw.	sw.	wsw.	......	......	....	4 3	Ci.-Cu. Cu.	w. w.	
Aug. 11...	6	wsw.	wnw.	wnw.	nw.	......	CW.	Few.	Ci.-St.	(?)	
Aug. 20...	2	s.[1]	Calm.	w.	......	......	CW.	4	Cu.	wsw.	
Aug. 23...	7	w.	wnw.	......	......	......	CW.	1 1	A.-Cu. St.-Cu.	w. w.	
Aug. 24...	0	Calm.	s.	s.	......	......	....	5 5	Cu. St.-Cu.	wsw. wsw.	Thunderstorm; light rain.
Aug. 26...	1	e.[2]	Calm.	sw.	......	......	CW.	10	St.	se.	
Sept. 3....	8	w.	wnw.	nw.	wnw.	wnw.	CW.	3 2	Ci. A.-Cu.	wnw. wnw.	
Sept. 13...	9	nw.	nw.	nw.	nw.	nw.	....	Few. Few. Few.	Ci. A.-Cu. A.-St.	nw. nw. nw.	
	8	nw.	nw.	nw.	nw.	nw.	....	3 2	A.-Cu. A.-St.	nw. nw.	
	6	nw.	nnw.	nw.	nw.	......	....	6 4	A.-St. St.	nw. nnw.	
Sept. 16...	6	nw.	nw.	nw.	......	......	....	4 4	A.-Cu. St.	w. n.	
Sept. 25...	7	w.	wnw.	w.	w.	w.[2]	....	1 1 2	Ci.-Cu. A.-Cu. Cu.	w. w. w.	
Sept. 26...	10	nw.	nw.	nw.	nw.	nw.[3]	....	Few. Few. 5	Ci.-St. Ci.-Cu. St.-Cu.	wnw. nw. nw.	
Oct. 11...	10	wnw.	wnw.	w.	......	......	CCW.	6 2 Few.	A.-Cu. Cu. St.	wnw. wnw. wnw.	
Oct. 23...	5	wnw.	w.	......	......	......	CCW.	1	Ci.-St.	sw.	
Nov. 1....	9	nw.	nw.	nw.	w.	wsw.	CCW.	7	St.-Cu.	nw.	
Nov. 21...	14	wnw.	nw.	nw.	nw.	......	CW.	5	St.-Cu.	nw.	
Nov. 25...	8	wnw.	wnw.	wnw.	wnw.	......	....	7	St.-Cu.	wnw.	Light snow.
Nov. 26...	7	ssw.	wsw.	w.	......	......	CW.	3	A.-Cu.	w.	
Dec. 1....	5	sw.[1]	wsw.	w.	w.	wsw.[4]	CW.	1 3 2	Ci.-St. Ci.-Cu. A.-Cu.	wsw. w. w.	
Dec. 13...	15	nw.	wnw.	w.	wsw.	......	CCW.	4 4	A.-St. St.-Cu.	w. wsw.	
1912.											
Jan. 1.....	14	wnw.	wnw.	wnw.	......	......	....	5 5	Ci.-St. A.-St.	wsw. sw.	Solar halo.
	10	nw.	wnw.	wnw.	w.	wsw.	CCW.	3 3	Ci.-St. A.-St.	sw. sw.	Solar halo.
Jan. 4.....	4	wnw.	wnw.	w.	......	......	CCW.	1 4	Ci. St.-Cu.	(?) wnw.	Light haze.
Jan. 5.....	25	wnw.	wnw.	wnw.	......	......	....	8	St.	wnw.	
Jan. 16....	22	wnw.	wnw.	......	......	......	....	Few.	St.-Cu.	wnw.	
Feb. 1....	6	wnw.	wnw.	wnw.	wnw.	......	....	5 5	Ci.-St. St.-Cu.	w. wnw.	Solar halo.
Feb. 3....	8	wnw.	w.	w.	w.	......	CCW.	4 4	Ci.-St. Ci.-Cu.	w. w.	Solar halo.
Feb. 4....	16	nw.	wnw.	nw.	......	......	....	0	....	......	
Feb. 8....	9	w.	w.	w.	......	......	....	5	St.-Cu.	w.	Light snow.
	14	wnw.	w.	w.	w.	......	CCW.	0	....	......	
	8	wnw.	wnw.	wnw.	wnw.	......	....	0	....	......	
	10	wnw.	wnw.	wnw.	wnw.	......	....	0	....	......	
Feb. 9....	3	s.	wsw.	wnw.	......	......	CW.	Few.	A.-Cu.	w.	

*CW. and CCW. represent clockwise and counter-clockwise, respectively.

[1] Variable. [2] w. at 5,000 m. [3] nw. at 5,000 m. [4] wsw. at 5,000 m.

TABLE XIII.—*Low NE. or E.; high NW., W., or SW., of Mount Weather.*

Date.	Wind velocity at surface.	Wind direction at— Surface 526 m.	1,000 m.	2,000 m.	3,000 m.	4,000 m.	Turning CW. or CCW.*	Clouds. Amt.	Kind.	Dis.	Remarks.
1912.	*m.p.s.*										
Feb. 20...	10	nw.	wnw.	w.	......	......	CCW.	10	A.-St.	w.	
								Few.	St.	wnw.	
Feb. 25...	10	wnw.	nw.	nw.	wnw.	wnw.	....	5	Ci.	wnw.	Solar halo.
								5	St.-Cu.	nw.	
Feb. 28...	7	w.	w.	wnw.	w.	......	....	Few.	A.-Cu.	wnw.	
Mar. 18...	11	w.	w.	w.	w.	w.	....	3	Ci.-St.	w.	Parhelia.
								2	Ci.-Cu.	w.	
Mar. 20...	6	wnw.	wnw.	wnw.	wnw.	wnw.	....	5	Ci.-St.	w.	
								3	A.-Cu.	wnw.	
								2	St.-Cu.	wnw.	
Mar. 27...	4	wnw.	wsw.	w.	w.	......	CCW.	4	Ci.-St.	w.	Solar halo; light haze.
								Few.	St.-Cu.	wnw.	
Apr. 3....	16	nw.	nw.	nw.	nw.	......	....	5	St.-Cu.	nw.	Light snow.
Apr. 23...	19	wnw.	wnw.	nw.	nw.	......	CW.	Few.	Cu.	nw.	
May 2....	6	wnw.	wnw.	wnw.	wnw.	wnw.[1]	....	5	Ci.-St.	wnw.	
								Few.	Cu.	wnw.	
May 21...	6	w.	wnw.	wnw.	w.	......	....	0	......	......	
May 25...	10	nw.	nw.	nw.	wnw.	wnw.[1]	CCW.	5	Ci.-St.	w.	Solar halo.
								5	A.-Cu.	w.	
June 3....	12	nw.	nw.	wnw.	wnw.	wnw.	CCW.	5	Ci.-St.	w.	Solar halo.
								2	A.-St.	nw.	
								2	St.-Cu.	wnw.	
June 7....	8	nw.	nw.	nw.	nw.	w.	CCW.	6	Ci.-St.	sw.	Solar halo.
								4	St.-Cu.	nw.	
June 12...	8	w.	w.	w.	wnw.	wnw.	CW.	1	Ci.	wnw.	
June 20...	9	wnw.	wnw.	wnw.	wnw.	......	....	Few.	Ci.-St.	wsw.	
								2	Cu.	wnw.	
June 21...	4	w.	wnw.	......	......	......	CW.	Few.	A.-St.	(?)	
June 26...	6	w.	wnw.	......	......	......	CW.	9	Ci.-St.	w.	Solar halo.
June 29...	9	wnw.	wnw.	wnw.	wnw.	......	....	2	Ci.	wsw.	
								3	Ci.-Cu.	wsw.	
June 30...	8	nw.	nw.	nnw.	nw.	......	....	5	A.-St.	wnw.	Light rain.
								5	St.-Cu.	wnw.	

*CW. and CCW. represent clockwise and counter-clockwise, respectively.

[1] wnw. at 5,000 m.

TABLE XIV.—*Low moving up Atlantic coast; high N. of Mount Weather.*

Date.	Wind velocity at surface.	Wind direction at— Surface 526 m.	1,000 m.	2,000 m.	3,000 m.	4,000 m.	Turning CW. or CCW.*	Clouds. Amt.	Kind.	Dir.	Remarks.
1911.	*m.p.s.*										
July 1....	4	nw.	nnw.	......	......	......	CW.	7 Few.	Ci. Cu.	nw. nnw.	
July 2....	7	wnw.	nnw.	nne.	nne.	nne.	CW.	4 4	Ci.-St. A.-Cu.	nne. nne.	Solar halo.
July 3....	5	wnw.	nne.	nne.	nne.	......	CW.	4 2	Ci. St.-Cu.	n. n.	
July 4....	2	se.[1]...	sse.	ene.	......	......	CCW.	2 2	Ci.-Cu. A.-Cu.	ne. ene.	Solar halo.
July 7....	8	ne.[1]	ene.	......	......	......	CW.	10 Lt.	St. Fog.	ne. ne.	Light rain.
July 13...	3	nnw.[1]	n.	wnw.	......	......	CCW.	2	Ci.-St.	w.	
Aug. 5....	3	e.	Calm.	Calm.	......	......	......	10	St.	e.	Light rain.
Aug. 6....	3	e.	e.	ese.	......	......	CW.	10	St.-Cu.	e.	
Aug. 9....	6	nw.	nnw.	nnw.	......	......	CW.	2 Few. 1	Ci.-St. Ci.-Cu. St.-Cu.	wnw. sw. nnw.	Light haze.
Aug. 10...	3	se.	Calm.	nnw.	n.	......	CW.	4	Ci.-St.	nw.	
Aug. 22...	4	se.	se.	ne.	......	......	CCW.	Few.	Ci.-St.	(?)	
Aug. 29...	9	nnw.	nne.	nne.	......	......	CW.	Dense.	Fog.	nnw.	Light rain.
Aug. 31...	8	nnw.	nnw.	......	......	......	......	Dense.	Fog.	nnw.	Light rain.
Sept. 17...	3	nw.[1]	ne.	nne.	nne.	n.	CW.	Few.	Ci.	wnw.	
Sept. 20...	8	nw.	nnw.	......	......	......	CW.	4	St.-Cu.	nw.	
Oct. 12...	9	nw.	n.	n.	n.	......	CW.	6 Few.	St.-Cu. St.	n. nw.	
Oct. 19...	8	nw.	nnw.	nne.	nne.	......	CW.	2 5 2	Ci.-St. A.-St. A.-Cu.	nw. w. wnw.	
·912.											
Jan. 3....	2	n.[1]	n.	w.	......	......	CCW.	3 7	A.-St. St.-Cu.	w. w.	
Feb. 11...	7	nw.	n.	......	......	......	CW.	6	Ci.-St.	w.	
Apr. 30...	8	nnw.	nw.	......	......	......	CCW.	Dense.	Fog.	nnw.	
May 10...	12	wnw.	nw.	nnw.	nnw.	nnw.	CW.	0	....	......	

*CW. and CCW. represent clockwise and counter-clockwise, respectively.

[1] Variable.

TABLE XV.—*Distribution of mean wind directions about centers of high pressure.*

Octant.	Distance from center.	526 m.		1,000 m.		2,000 m.		3,000 m.		4,000 m.		5,000 m.		6,000 m.		7,000 m.	
		Observations.	Angle.	Observations.	Angle.	Observations.	Angle.	Observations.	Angle.	Observations.	Angle.	Observations.	Angle.	Observations.	Angle.	Observations.	Angle.
	Kilometers.																
I.....	0- 500	32	47	32	37	27	30	23	31	13	33	5	34	2	33	1	68
	500-1,000	30	52	30	44	25	31	16	30	6	53	4	69	2	33	1	68
	1,000-2,000	36	39	36	37	33	39	19	46	9	48	3	30	1	23	....	....
II....	0- 500	21	64	21	39	18	21	13	14	7	10	2	10	1	0	....	....
	500-1,000	23	58	23	21	19	10	15	13	7	19	2	33	1	24	....	....
	1,000-2,000	11	42	11	42	10	35	6	40	3	22	....	....	....	....	....	....
III...	0- 500	28	54	28	15	24	− 4	17	− 7	5	− 12	5	− 14	2	−13	....	....
	500-1,000	10	49	10	11	9	15	5	26	4	33	2	34	1	23	....	....
	1,000-2,000	10	33	10	19	9	23	4	22	2	0	....	....	....	....	....	....
IV...	0- 500	29	59	29	− 4	22	−27	11	−49	2	− 79	1	− 68	....	....	....	....
	500-1,000	31	20	30	− 9	27	−36	19	−38	13	− 39	3	− 30	1	−46	....	....
	1,000-2,000	3	41	3	−22	3	−34	1	−22	....	....	....	....	....	....	....	....
V....	0- 500	26	36	26	−22	18	−62	9	−80	6	−106	2	−102	....	....	....	....
	500-1,000	43	19	43	−15	35	−48	16	−74	7	− 72	3	− 61	3	−61	3	− 61
	1,000-2,000	22	17	22	−20	17	−48	8	−68	4	− 85	2	−102	....	....	....	....
VI...	0- 500	17	45	17	0	13	−26	8	−82	2	−134	....	....	....	....	....	....
	500-1,000	43	24	43	− 6	30	−35	9	−24	2	−136	2	−135	....	....	....	....
	1,000-2,000	15	−20	15	−41	7	−37	4	−71	1	− 90	1	− 90	....	....	....	....
VII..	0- 500	20	44	20	23	15	60	7	88	2	112	1	135	....	....	....	....
	500-1,000	44	52	44	18	31	64	15	82	8	119	5	112	2	146	....	....
	1,000-2,000	8	78	8	59	6	92	1	68	....	....	....	....	....	....	....	....
VIII.	0- 500	21	54	21	47	16	44	11	61	3	88	....	....	....	....	....	....
	500-1,000	57	73	57	64	49	63	33	69	11	78	3	116	....	....	....	....
	1,000-2,000	33	83	32	85	30	96	21	98	7	98	....	....	....	....	....	....

TABLE XVI.—*Distribution of mean wind directions about centers of low pressure.*

Octant.	Distance from center.	526 m.		1,000 m.		2,000 m.		3,000 m.		4,000 m.		5,000 m.		6,000 m.		7,000 m.	
		Observations.	Angle.	Observations.	Angle.	Observations.	Angle.	Observations.	Angle.	Observations.	Angle.	Observations.	Angle.	Observations.	Angle.	Observations.	Angle.
	Kilometers.																
I.....	0- 500	5	22	5	−22	5	−37	1	−45	....	....	....	....	....	....	....	....
	500-1,000	8	48	8	13	4	−17	2	12	1	0	....	....	....	....	....	....
	1,000-2,000	2	79	2	32	1	−45	....	....	....	....	....	....	....	....	....	....
II....	0- 500	3	−15	3	−26	....	....	....	....	....	....	....	....	....	....	....	....
	500-1,000	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
	1,000-2,000	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
III...	0- 500	7	63	7	25	6	60	3	52	3	36	2	57	1	22	....	....
	500-1,000	3	− 5	3	3	3	95	1	56	1	22	....	....	....	....	....	....
	1,000-2,000	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
IV...	0- 500	16	57	16	52	9	55	6	62	4	63	2	57	....	....	....	....
	500-1,000	21	43	21	36	18	39	10	49	4	57	....	....	....	....	....	....
	1,000-2,000	26	47	26	37	23	35	19	30	6	33	2	12	1	22	1	22
V....	0- 500	7	34	7	46	6	49	5	50	....	....	....	....	....	....	....	....
	500-1,000	29	36	29	34	27	37	12	38	7	38	2	23	....	....	....	....
	1,000-2,000	60	20	60	19	59	25	34	30	13	29	3	30	....	....	....	....
VI...	0- 500	14	60	13	32	13	29	9	23	5	22	....	....	....	....	....	....
	500-1,000	65	15	64	12	61	10	39	10	21	16	6	7	1	0	....	....
	1,000-2,000	20	11	20	10	19	10	14	8	7	12	2	11	....	....	....	....
VII..	0- 500	9	40	9	− 9	7	−16	2	−45	1	− 68	....	....	....	....	....	....
	500-1,000	29	18	29	15	28	− 2	16	− 3	6	21	....	....	....	....	....	....
	1,000-2,000	19	30	19	− 6	16	− 7	10	− 6	4	− 22	1	− 22	1	−22	....	....
VIII.	0- 500	7	3	7	−32	5	−40	2	23	....	....	....	....	....	....	....	....
	500-1,000	7	66	7	11	6	− 6	2	0	1	− 45	....	....	....	....	....	....
	1,000-2,000	7	37	7	−28	6	−39	3	−30	3	− 30	....	....	....	....	....	....

TABLE XVII.—*Vertical distribution of absolute humidity in Highs and Lows.*

Months.	Level.	H_f.		H_r.		L_f.		L_r.		H→L.		L→H.		H.		L.		All conditions.	
	Kilometers above sea level.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.
December	0.526	10	2.6	5	4.4	5	7.0	3	5.7	13	3.3	10	5.7	15	3.2	8	6.5	23	4.3
	1.0	10	2.2	5	4.5	5	7.7	3	4.4	13	2.7	10	6.3	15	2.9	8	6.5	23	4.2
	1.5	8	2.1	5	4.4	5	6.4	3	3.0	11	2.4	10	5.4	13	3.0	8	5.1	21	3.8
	2.0	5	2.1	5	4.0	5	4.4	3	2.5	8	2.3	10	4.2	10	3.0	8	3.7	18	3.3
	2.5	4	2.0	4	3.8	3	1.9	2	2.5	6	2.2	7	3.0	8	2.9	5	2.1	13	2.6
	3.0	3	1.4	2	2.7	2	1.5	2	2.2	5	1.7	4	2.1	5	1.9	4	1.9	9	1.8
January	0.526	9	1.8	6	2.0	4	2.4	8	2.7	17	2.2	10	2.2	15	1.9	12	2.6	27	2.2
	1.0	9	1.4	6	2.6	4	2.1	8	2.3	17	1.8	10	2.5	15	1.9	12	2.2	27	2.1
	1.5	9	1.2	6	2.7	4	2.1	8	1.9	17	1.5	10	2.5	15	1.8	12	2.0	27	1.9
	2.0	9	1.1	6	2.7	4	2.0	6	2.1	15	1.5	10	2.4	15	1.8	10	2.0	25	1.8
	2.5	7	1.0	6	2.3	2	0.6	5	1.6	12	1.2	8	1.9	13	1.6	7	1.3	20	1.5
	3.0	6	1.0	6	1.8	2	0.3	2	0.8	8	0.9	8	1.4	12	1.4	4	0.6	16	1.2
February	0.526	9	1.4	4	2.2	5	5.1	7	2.1	16	1.7	9	3.8	13	1.7	12	3.3	25	2.5
	1.0	8	1.1	4	2.0	5	4.6	7	1.6	15	1.3	9	3.4	12	1.4	12	2.9	24	2.1
	1.5	7	1.0	4	1.6	4	4.9	7	1.1	14	1.1	8	3.3	11	1.2	11	2.5	22	1.9
	2.0	5	1.1	3	1.1	3	4.4	6	0.8	11	0.9	6	2.5	8	1.1	9	2.0	17	1.6
	2.5	3	1.0	3	1.0	1	2.1	4	0.6	7	0.8	4	1.3	6	1.0	5	0.9	11	1.0
	3.0	3	0.8	1	1.2	1	1.4	2	0.4	5	0.6	2	1.3	4	0.9	3	0.7	7	0.8
Winter	0.526	28	2.0	15	2.8	14	5.0	18	3.0	46	2.4	29	3.9	43	2.3	32	3.9	75	3.0
	1.0	27	1.6	15	3.1	14	5.0	18	2.4	45	1.9	29	4.0	42	2.1	32	3.5	74	2.7
	1.5	24	1.4	15	3.0	14	4.3	18	1.8	42	1.6	29	3.6	39	2.1	32	2.9	71	2.4
	2.0	19	1.4	14	2.8	12	3.6	15	1.7	34	1.5	26	3.2	33	2.0	27	2.5	60	2.2
	2.5	14	1.3	13	2.4	6	1.5	11	1.4	25	1.3	19	2.2	27	1.9	17	1.4	44	1.7
	3.0	12	1.0	9	1.9	5	1.0	6	1.1	18	1.1	14	1.6	21	1.4	11	1.1	32	1.3

TABLE XVIII.—*Vertical distribution of absolute humidity in Highs and Lows.*

Months.	Level.	H_f.		H_r.		L_f.		L_r.		H→L.		L→H.		H.		L.		All conditions.	
	Kilometers above sea level.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.
March	0.526	10	2.9	10	4.2	5	6.3	5	5.3	15	3.7	15	4.9	20	3.6	10	5.8	30	4.3
	1.0	10	2.0	10	3.3	5	6.6	5	4.4	15	2.8	15	4.4	20	2.6	10	5.5	30	3.6
	1.5	8	1.4	10	2.8	5	5.7	4	2.7	12	1.8	15	3.7	18	2.2	9	4.3	27	2.9
	2.0	6	0.8	10	2.2	4	4.8	4	2.0	10	1.3	14	3.0	16	1.7	8	3.4	24	2.3
	2.5	5	0.5	10	1.9	1	4.1	3	1.2	8	0.8	11	2.1	15	1.4	4	1.9	19	1.5
	3.0	5	0.4	7	1.3	1	3.0	2	0.6	7	0.5	8	1.5	12	0.9	3	1.4	15	1.0
April	0.526	6	3.7	11	7.4	6	9.2	6	6.0	12	4.8	17	8.0	17	6.1	12	7.6	29	6.7
	1.0	6	2.9	11	6.2	5	8.5	6	4.9	12	3.9	16	6.9	17	5.0	11	6.6	28	5.6
	1.5	6	2.2	11	5.3	5	7.2	5	4.1	11	3.0	16	5.9	17	4.2	10	5.7	27	4.7
	2.0	6	1.8	11	4.4	5	6.0	4	2.1	10	1.9	16	4.9	17	3.5	9	4.3	26	3.8
	2.5	5	1.5	10	3.5	4	4.8	4	1.6	9	1.5	14	3.9	15	2.8	8	3.2	23	3.0
	3.0	4	1.2	7	2.8	3	4.1	4	1.1	8	1.2	10	3.2	11	2.2	7	2.4	18	2.3
May	0.526	8	7.2	10	9.0	3	12.0	7	10.1	15	8.6	13	9.7	18	8.2	10	10.7	28	9.1
	1.0	7	6.[illegible]	10	7.1	3	10.6	7	8.2	14	7.1	13	7.9	17	6.6	10	8.9	27	7.5
	1.5	7	4.5	8	5.4	3	8.1	7	6.1	14	5.3	11	6.1	15	5.0	10	6.7	25	5.7
	2.0	7	3.4	7	3.7	3	5.9	6	4.6	13	4.0	10	4.4	14	3.6	9	5.0	23	4.1
	2.5	7	2.6	6	2.4	3	4.6	5	3.1	12	2.8	9	3.1	13	2.5	8	3.6	21	2.9
	3.0	6	2.1	3	2.2	3	3.4	5	2.0	11	2.0	6	2.8	9	2.1	8	2.5	17	2.3
Spring	0.526	24	4.5	31	6.9	14	8.8	18	7.4	42	5.8	45	7.5	55	5.8	32	8.0	87	6.6
	1.0	23	3.4	31	5.5	13	8.2	18	6.0	41	4.6	44	6.3	54	4.6	31	7.0	85	5.5
	1.5	21	2.7	29	4.4	13	6.7	16	4.6	37	3.5	42	5.1	50	3.7	29	5.6	79	4.4
	2.0	19	2.1	28	3.5	12	5.6	14	3.2	33	2.5	40	4.1	47	2.9	26	4.3	73	3.4
	2.5	17	1.7	26	2.6	8	4.6	12	2.1	29	1.8	34	3.1	43	2.2	20	3.1	63	2.5
	3.0	15	1.3	17	2.1	7	3.6	11	1.4	26	1.4	24	2.5	32	1.7	18	2.3	50	1.9

TABLE XIX.—*Vertical distribution of absolute humidity in Highs and Lows.*

Months.	Level.	H_f.		H_r.		L_f.		L_r.		H⟶L.		L⟶H.		H.		L.		All conditions.	
	Kilometers above sea level.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.
June	0.526	7	8.2	6	14.4	3	11.5	6	13.0	13	10.4	9	13.4	13	11.0	9	12.5	22	11.6
	1.0	7	6.2	6	11.8	3	11.0	6	10.6	13	8.2	9	11.5	13	8.8	9	10.7	22	9.6
	1.5	6	4.4	4	9.7	2	9.2	6	8.1	12	6.2	6	9.5	10	6.6	8	8.3	18	7.4
	2.0	5	3.0	3	7.7	2	8.1	6	6.2	11	4.7	5	7.8	8	4.7	8	6.7	16	5.7
	2.5	5	2.1	2	6.0	1	8.2	6	4.6	11	3.4	3	6.7	7	3.2	7	5.1	14	4.1
	3.0	5	1.7	1	4.4	1	6.5	6	3.4	11	2.6	2	5.4	6	2.1	7	3.8	13	3.0
July	0.526	4	14.4	7	12.8	3	15.2	4	11.4	8	12.9	10	13.5	11	13.4	7	13.0	18	13.3
	1.0	4	10.8	7	10.4	3	12.6	4	8.9	8	9.9	10	11.1	11	10.6	7	10.5	18	10.6
	1.5	3	8.3	6	8.6	3	10.4	4	7.0	7	7.6	9	9.2	9	8.5	7	8.5	16	8.5
	2.0	3	6.9	2	5.6	3	8.2	3	4.3	6	5.6	5	7.1	5	6.4	6	6.2	11	6.3
	2.5	2	6.5	1	1.6	3	6.0	3	2.9	5	4.4	4	4.9	3	4.9	6	4.4	9	4.6
	3.0	2	4.5	1	1.1	2	4.3	3	2.1	5	3.0	3	3.2	3	3.4	5	3.0	8	3.1
August	0.526	4	17.1	3	14.7	4	16.8	6	13.2	10	14.8	7	15.9	7	16.1	10	14.6	17	15.2
	1.0	4	10.7	3	11.0	4	13.9	6	10.0	10	10.3	7	12.4	7	10.8	10	11.6	17	11.3
	1.5	3	10.1	2	9.4	2	11.0	6	7.4	9	8.3	4	10.2	5	9.8	8	8.3	13	8.9
	2.0	2	8.1	1	7.7	2	8.5	5	4.9	7	5.9	3	8.2	3	8.0	7	5.9	10	6.6
	2.5	1	6.5	1	5.2	2	6.9	5	3.5	6	4.0	3	6.3	2	5.9	7	4.5	9	4.8
	3.0	0	....	0	....	2	5.7	5	2.8	5	2.8	2	5.7	0	....	7	3.6	7	3.6
Summer	0.526	15	12.2	16	13.7	10	14.7	16	12.7	31	12.5	26	14.1	31	13.0	26	13.5	57	13.2
	1.0	15	8.6	16	11.1	10	12.6	16	10.0	31	9.3	26	11.7	31	9.9	26	11.0	57	10.4
	1.5	12	6.8	12	9.1	7	10.2	16	7.6	28	7.2	19	9.5	24	8.0	23	8.4	47	8.2
	2.0	10	5.2	6	7.0	7	8.2	14	5.4	24	5.3	13	7.6	16	5.8	21	6.3	37	6.1
	2.5	8	3.7	4	4.7	6	6.6	14	3.8	22	3.8	10	5.9	12	4.0	20	4.7	32	4.4
	3.0	7	2.5	2	2.2	5	5.3	14	2.9	21	2.8	7	4.4	9	2.5	19	3.5	28	3.2

TABLE XX.—*Vertical distribution of absolute humidity in Highs and Lows.*

Months.	Level.	H_t.		H_r.		L_t.		L_r.		H→L.		L→H.		H.		L.		All conditions.	
	Kilometers above sea level.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.
September	0.526	7	11.2	7	11.5	2	15.1	3	14.4	10	12.2	9	12.3	14	11.4	5	14.7	19	12.2
	1.0	7	9.0	7	10.2	2	12.5	3	10.6	10	9.5	9	10.7	14	9.6	5	11.4	19	10.1
	1.5	6	6.4	6	9.0	2	11.8	3	9.3	9	7.4	8	9.7	12	7.7	5	10.3	17	8.5
	2.0	6	4.3	4	5.8	2	9.7	2	6.4	8	4.8	6	7.1	10	4.9	4	8.1	14	5.8
	2.5	5	3.7	3	5.4	2	7.0	2	4.9	7	4.0	5	6.0	8	4.4	4	5.9	12	4.9
	3.0	5	3.1	3	4.2	2	6.6	2	3.9	7	3.3	5	5.1	8	3.5	4	5.2	12	4.1
October	0.526	7	6.9	5	7.5	4	10.6	2	10.8	9	7.8	9	8.9	12	7.2	6	10.7	18	8.3
	1.0	7	5.4	5	6.4	4	9.6	2	9.9	9	6.4	9	7.8	12	5.8	6	9.7	18	7.1
	1.5	7	4.0	3	6.7	2	9.3	2	8.3	9	5.0	5	7.7	10	4.8	4	8.8	14	6.0
	2.0	7	2.7	3	6.9	2	7.7	2	6.0	9	3.5	5	7.2	10	4.0	4	6.9	14	4.8
	2.5	2	1.4	2	6.7	2	5.9	1	5.8	3	2.8	4	6.3	4	4.0	3	5.9	7	4.8
	3.0	2	0.9	2	5.7	1	3.7	......	......	2	0.9	3	5.0	4	3.3	1	3.7	5	3.4
November	0.526	10	3.0	6	4.3	3	4.5	6	3.8	16	3.3	9	4.4	16	3.5	9	4.0	25	3.7
	1.0	10	2.2	6	3.9	3	4.9	6	2.9	16	2.4	9	4.2	16	2.8	9	3.6	25	3.1
	1.5	9	1.8	5	3.5	3	4.4	6	1.9	15	1.8	8	3.8	14	2.4	9	2.8	23	2.5
	2.0	7	1.6	5	3.3	2	2.5	3	1.0	10	1.4	7	3.0	12	2.3	5	1.6	17	2.1
	2.5	6	1.0	5	2.8	......	......	1	1.0	7	1.0	5	2.8	11	1.8	1	1.0	12	1.8
	3.0	3	0.9	5	2.4	......	......	......	......	3	0.9	5	2.4	8	1.8	......	......	8	1.8
Autumn	0.526	24	6.6	18	8.0	9	9.6	11	7.9	35	7.0	27	8.5	42	7.2	20	8.7	62	7.7
	1.0	24	5.1	18	7.0	9	8.7	11	6.2	35	5.5	27	7.6	42	5.9	20	7.4	62	6.4
	1.5	22	3.8	14	6.5	7	7.9	11	5.1	33	4.2	21	7.0	36	4.8	18	6.2	54	5.3
	2.0	20	2.8	12	5.0	6	6.6	7	4.0	27	3.1	18	5.6	32	3.6	13	5.2	45	4.1
	2.5	13	2.1	10	4.4	4	6.4	4	4.1	17	2.6	14	5.0	23	3.1	8	5.3	31	3.7
	3.0	10	2.0	10	3.6	3	5.6	2	3.9	12	2.3	13	4.1	20	2.8	5	4.9	25	3.2

TABLE XXI.—*Vertical distribution of absolute humidity in Highs and Lows.*

Months.	Level.	H_f.		H_r.		L_f.		L_r.		H⟶L.		L⟶H.		H.		L.		All conditions.	
	Kilometers above sea level.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter.	Number of observations.	Grams per cubic meter. mmmm	Number of observations.	Grams per cubic meter.
Year	0.526	91	5.5	80	7.7	47	9.1	63	7.6	154	6.4	127	8.2	171	6.6	110	8.2	281	7.2
	1.0	89	4.2	80	6.5	46	8.3	63	6.0	152	5.0	126	7.2	169	5.3	109	7.0	278	6.0
	1.5	79	3.2	70	5.4	41	6.7	61	4.6	140	3.9	111	5.8	149	4.2	102	5.5	251	4.7
	2.0	68	2.6	60	4.0	37	5.6	50	3.4	118	2.9	97	4.6	128	3.2	87	4.4	215	3.7
	2.5	52	2.0	53	3.1	24	4.7	41	2.7	93	2.3	77	3.5	105	2.5	65	3.4	170	2.9
	3.0	44	1.6	38	2.4	20	3.7	33	2.1	77	1.8	58	2.9	82	2.0	53	2.7	135	2.3

TABLE XXII.—*Relative frequency (per cent) of winds from the different directions observed at each level.*

Wind direction.	Altitude of each level (meters).											
	526	750	1,000	1,250	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000
N	0.2	2.5	2.2	1.7	2.0	2.8	2.2	1.9	1.8			
NNE			1.1	1.2	1.8	1.6	2.2	1.9	1.2	1.9	1.7	
NE	0.4		0.4	0.4	0.2							
ENE	0.4	0.2	0.2	0.4								
E	3.5	1.6	0.9	0.8	0.8	0.5						
ESE	2.6	2.0	2.2	1.0	0.8							
SE	14.1	3.2	2.4	2.1	0.8	0.2	0.3					
SSE	9.6	10.6	6.2	3.7	2.0	0.9						
S	7.5	12.4	12.4	9.0	6.4	2.5	0.8	0.7				
SSW	0.7	6.5	7.6	11.5	10.4	8.8	7.8	5.6	3.6	1.0		
SW	2.1	3.4	5.6	8.0	10.0	12.5	14.1	13.0	13.6	9.4	6.9	12.5
WSW	3.5	3.4	4.9	5.6	6.8	7.6	7.2	13.0	15.4	16.0	8.6	4.1
W	8.9	7.4	7.6	8.7	10.2	18.1	23.0	22.7	21.9	28.3	36.2	50.0
WNW	26.4	20.1	19.5	18.8	19.0	19.7	18.8	21.3	25.4	31.1	29.3	12.5
NW	17.0	19.4	19.3	19.5	19.2	17.8	18.3	14.5	13.6	8.5	12.1	8.3
NNW	3.3	7.2	7.6	7.5	9.4	6.9	5.3	5.6	3.6	3.8	5.2	12.5

TABLE XXIII.—*Mean velocity of winds from each of the 16 points at each level.*

SPRING.

Wind direction.	526 (surface).		750		1,000		1,250		1,500	
	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.
		m.p.s.		*m.p.s.*		*m.p.s.*		*m.p.s.*		*m.p.s.*
N			3	10.0	4	9.0			1	3.9
NNE										
NE	2	3.6								
ENE										
E	4	5.2	2	10.6	1	16.3				
ESE	3	5.5	1	6.6	2	10.3				
SE	30	8.1	5	6.4	4	7.6	6	9.7	1	11.9
SSE	30	7.9	24	11.5	12	11.8	3	12.2	3	8.9
S	11	5.9	35	11.7	33	13.9	23	12.8	16	14.1
SSW			10	11.6	18	13.5	26	13.8	18	15.5
SW	2	5.4	4	13.9	7	15.9	19	14.6	27	15.2
WSW	7	6.8	5	10.4	9	16.9	11	17.1	12	14.2
W	18	8.4	13	11.5	17	13.5	16	16.2	19	17.0
WNW	38	11.0	34	12.7	28	15.2	25	14.6	26	15.0
NW	30	11.6	30	14.3	27	16.6	17	19.6	26	17.9
NNW	2	7.2	4	12.6	10	15.8	11	16.7	12	16.0

Wind direction.	2,000		2,500		3,000		3,500		4,000		4,500		5,000	
	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.
		m.p.s.		*m.p.s.*		*m.p.s.*		*m.p.s.*		*m.p.s.*		*m.p.s.*		*m.p.s.*
N														
NNE														
NE														
ENE														
E														
ESE														
SE														
SSE	2	11.2												
S	6	14.0	1	15.9										
SSW	17	16.5	15	17.8	9	17.8	2	19.8						
SW	28	15.5	26	16.0	17	18.5	10	18.1	3	23.6				
WSW	14	17.2	11	18.4	10	20.1	9	20.1	3	20.7	1	25.8		
W	24	18.8	25	19.0	23	22.0	20	23.4	17	22.0	10	21.9	7	26.4
WNW	25	16.2	23	17.5	19	21.2	12	20.6	13	25.9	7	24.5		
NW	23	20.7	20	23.8	12	22.3	8	21.4	3	18.0	2	18.6	1	19.0
NNW	12	14.2	5	14.8	6	19.2	4	22.1	3	23.0	3	22.3	3	25.7

TABLE XXIII.—*Mean velocity of winds from each of the 16 points at each level*—Continued.

SUMMER.

Wind direction.	526 (surface).		750		1,000		1,250		1,500		2,000		2,500		3,000		3,500		4,000		4,500		5,000	
	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.	Number of observations.	Mean velocity.
		m.p.s.		*m.p.s.*		*m.p.s.*		*m.p.s.*		*m.p.s.*		*m.p.s.*		*m.p.s.*		*m.p.s.*		*m.p.s.*		*m.p.s.*		*m.p.s.*		*m.p.s.*
N			6	9.6	4	10.8	5	10.8	5	9.3	7	10.5	5	10.7	3	16.3								
NNE					4	13.1	4	10.5	5	9.3	3	11.5	4	11.3	4	14.0	2	14.4	2	17.2	1	24.5		
NE																								
ENE			1	8.5	1	10.2	2	10.4																
E	9	5.8	3	8.8	2	7.7	2	8.8	2	10.9	2	15.0												
ESE	4	7.9	6	6.9	6	8.8	2	10.6	2	11.0														
SE	15	6.7	7	10.6	4	10.0	2	8.4	1	7.0			1	18.3										
SSE	7	7.7	10	8.7	12	10.0	11	9.0	4	5.7														
S	9	6.3	12	10.8	9	12.9	8	10.1	10	10.1	5	10.6	2	10.8	2	12.8								
SSW			2	13.5	4	12.9	6	14.0	6	14.8	6	17.2	4	18.3	2	24.6	2	25.4	1	24.6				
SW	2	2.6	4	10.2	6	11.4	2	16.0	3	16.1	4	14.8	5	16.6	7	18.9	3	22.8	2	27.5				
WSW	6	5.9	3	9.6	2	10.7	4	11.9	4	13.1	1	10.3	2	16.5	1	20.8	3	22.0	4	23.0	1	30.6		
W	18	7.2	9	10.2	7	13.4	7	14.3	7	15.4	9	15.8	9	16.2	10	19.2	5	22.2	6	24.8	4	29.5	1	27.0
WNW	35	7.7	26	9.8	25	12.2	22	13.0	20	13.0	21	13.1	25	15.6	22	17.7	16	21.5	8	23.3	6	24.4	3	27.8
NW	19	7.9	28	10.6	32	11.6	33	12.9	29	14.3	21	16.6	17	15.9	10	16.8	5	20.4	2	13.8				
NNW	13	6.9	17	9.6	15	10.9	15	11.2	19	10.9	8	12.0	6	14.3	4	16.1								

AUTUMN.

N	1	2.8	2	7.4	3	14.0	4	12.0	3	11.7	4	9.8	3	10.2	2	11.7	3	13.2						
NNE					1	10.4	1	10.2	2	9.0	3	8.8	4	9.3	1	13.6								
NE					1	5.7	1	6.4	1	7.1														
ENE	1	5.4																						
E	3	5.8	2	7.2																				
ESE	3	6.9	1	7.9	2	7.0	1	6.6																
SE	19	7.6	3	7.2	3	9.9	2	8.0																
SSE	10	8.2	17	11.2	9	13.4	3	8.0	2	7.2														
S	8	7.7	11	12.0	10	12.6	9	14.1	4	19.3														
SSW			5	12.0	6	15.4	12	13.8	11	11.7	3	8.9	1	9.3	1	11.8								
SW	4	6.8	3	10.8	8	14.5	8	14.9	10	12.0	12	13.0	9	16.2	4	17.1	4	20.6	2	22.0	2	23.0	2	23.9
WSW	4	7.6	7	9.7	8	14.9	6	18.3	6	18.7	9	17.5	6	16.9	10	21.2	8	20.9	6	23.0	1	21.5	1	18.0
W	5	8.7	5	13.7	2	18.8	9	19.5	12	19.0	12	19.4	13	20.9	10	19.0	11	20.3	7	21.1	5	22.7	2	19.4
WNW	33	10.8	20	13.6	21	15.2	17	15.4	16	17.9	15	18.7	12	23.0	14	19.5	11	18.3	6	20.7	4	21.2		
NW	28	9.5	27	13.7	27	15.8	29	15.3	24	16.8	25	16.9	20	16.2	8	18.1	4	22.8	3	24.1	3	26.5	1	28.4
NNW	3	6.3	14	10.6	12	14.2	8	12.3	7	10.8	3	12.1	3	14.7	3	15.4	2	22.2	1	17.6				

WINTER.

N			3	9.0	1	21.9			1	10.2	1	11.8												
NNE					1	13.9	1	12.1	2	10.2	1	9.8												
NE					1	8.8	1	9.4																
ENE	1	4.0																						
E	4	5.3	2	8.4	2	10.2	2	7.4	2	5.2														
ESE	5	5.7	3	8.3	2	11.9	2	10.5	2	9.2														
SE	17	9.4	3	11.8	2	9.4	1	10.6	2	10.3	1	9.0												
SSE	8	6.5	8	11.0	1	13.3	2	9.7	1	8.2	2	9.6												
S	15	6.5	11	14.4	16	15.9	7	17.0	2	21.8														
SSW	4	5.7	19	11.1	14	14.2	16	16.1	17	16.2	12	17.1	8	17.2	3	21.4	2	23.2						
SW	4	6.8	8	9.9	10	12.3	13	14.9	10	17.5	10	19.3	11	19.1	9	20.5	6	22.5	3	17.3	2	15.7	1	20.4
WSW	3	6.0	4	10.0	8	15.1	8	14.3	12	15.5	9	13.0	7	19.1	15	22.0	6	24.8	4	23.2	2	24.8		
W	10	8.6	14	13.0	16	16.9	13	18.6	15	20.4	33	22.1	36	24.3	18	24.4	1	16.4			2	28.4	2	31.5
WNW	46	12.5	32	16.1	33	18.4	34	20.1	33	20.3	24	20.7	8	16.4	3	21.0	4	24.3	6	25.9				
NW	21	10.1	23	14.7	20	17.0	23	16.2	17	17.3	8	17.6	9	22.7	9	22.9	6	20.0	1	23.2	2	27.2		
NNW	1	5.8	5	14.6	5	16.5	5	15.6	9	14.5	7	16.0	5	14.1	2	18.2								

TABLE XXIII.—*Mean velocity of winds from each of the 16 points at each level*—Concluded.

YEAR.

Wind direction.	526 (surface). Number of observations.	526 (surface). Mean velocity.	750 Number of observations.	750 Mean velocity.	1,000 Number of observations.	1,000 Mean velocity.	1,250 Number of observations.	1,250 Mean velocity.	1,500 Number of observations.	1,500 Mean velocity.
		m.p.s.		*m.p.s.*		*m.p.s.*		*m.p.s.*		*m.p.s.*
N	1	2.8	14	9.2	12	11.9	9	11.3	10	9.6
NNE					6	12.8	6	10.7	9	9.4
NE	2	3.6			2	7.2	2	7.9	1	7.1
ENE	2	4.7	1	8.5	1	10.2	2	10.4		
E	20	5.6	9	8.7	5	10.4	4	8.1	4	8.0
ESE	15	6.5	11	7.4	12	9.3	5	9.8	4	10.1
SE	81	8.0	18	9.3	13	9.1	11	9.3	4	9.9
SSE	55	7.7	59	10.9	34	11.7	19	9.4	10	7.2
S	43	6.5	69	12.0	68	10.8	47	13.4	32	14.0
SSW	4	5.7	36	11.5	42	14.0	60	14.4	52	14.9
SW	12	5.9	19	10.9	31	13.5	42	14.8	50	15.9
WSW	20	6.6	19	10.0	27	15.3	29	15.8	34	15.3
W	51	8.0	41	12.0	42	14.6	45	17.3	51	18.9
WNW	152	10.7	112	13.1	107	13.8	98	16.3	95	16.9
NW	98	10.0	108	13.3	106	12.4	102	15.4	96	16.4
NNW	19	6.8	40	10.9	42	12.9	39	13.5	47	12.9

Wind direction.	2,000 Number of observations.	2,000 Mean velocity.	2,500 Number of observations.	2,500 Mean velocity.	3,000 Number of observations.	3,000 Mean velocity.	3,500 Number of observations.	3,500 Mean velocity.	4,000 Number of observations.	4,000 Mean velocity.	4,500 Number of observations.	4,500 Mean velocity.	5,000 Number of observations.	5,000 Mean velocity.
		m.p.s.		*m.p.s.*		*m.p.s.*		*m.p.s.*		*m.p.s.*		*m.p.s.*		*m.p.s.*
N	12	10.4	8	10.5	5	14.5	3	13.2						
NNE	7	10.1	8	10.3	5	13.9	2	14.4	2	17.2	1	24.5		
NE														
ENE														
E	2	15.0												
ESE														
SE	1	9.0	1	18.3										
SSE	4	10.4												
S	11	12.5	3	12.5	2	12.8								
SSW	38	16.2	28	17.4	15	19.1	6	22.8	1	24.6				
SW	54	15.6	51	16.8	35	18.3	23	20.3	10	22.2	4	19.4	3	22.7
WSW	33	16.0	26	18.1	36	21.2	26	21.7	17	22.6	5	25.5	1	18.0
W	78	19.9	83	21.4	61	21.7	37	22.2	30	22.4	21	24.2	12	26.2
WNW	85	17.1	68	17.6	58	19.4	43	20.7	33	24.3	17	23.7	3	27.8
NW	77	18.1	66	19.3	39	20.1	23	21.1	9	19.7	7	24.5	2	23.7
NNW	30	13.8	19	14.5	15	17.5	6	22.2	4	21.6	3	22.3	3	25.7

TABLE XXIV.—*General relation between surface air pressure and wind direction at the 1-kilometer level.*

Wind direction at 1,000 m.	H_1.	H_2.	H_3.	H_4.	L_1.	L_2.	L_3.	L_4.	H→L	L→H	$C_H \to C_L$	$C_L \to C_H$	Total Obs.
N	1	......	1	3	......	1	......	......	1	4	6	5	11
NNE	......	......	2	......	......	......	......	......	......	4	......	6	6
NE	......	......	1	......	......	......	......	......	......	1	......	2	2
ENE	......	......	......	......	......	......	......	......	......	1	......	1	1
E	......	......	5	......	......	......	......	......	......	......	......	5	5
ESE	......	......	3	2	......	2	......	1	1	4	5	8	13
SE	......	......	5	1	......	......	......	......	1	6	2	11	13
SSE	......	2	......	1	......	......	1	2	......	13	2	17	19
S	......	11	13	2	......	......	4	......	......	......	6	24	30
SSW	2	......	2	2	2	......	1	......	1	15	6	19	25
SW	3	7	2	......	......	......	4	......	......	11	7	20	27
WSW	2	......	......	......	......	......	6	......	6	6	14	6	20
W	3	2	......	2	......	6	13	3	14	1	38	6	44
WNW	......	5	......	4	......	7	......	1	......	2	11	8	19
NW	17	4	3	......	......	......	9	1	26	......	52	8	60
NNW	8	......	1	9	......	6	......	......	7	9	30	10	40

TABLE XXV.—*West components of winds at each level.*

SPRING.

Wind direction at 1,000 m.	Altitude, meters.											
	526 (surface).	750	1,000	1,250	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000
N	6.2	0.8	0	0	0	......	......	......	......	......	......	......
NNE	......	......	......	......	......	......	......	......	......	......	......	......
NE	......	......	......	......	......	......	......	......	......	......	......	......
ENE	......	......	......	......	......	......	......	......	......	......	......	......
E	−5.8	−10.8	−16.3	−11.5	− 4.3	− 3.5	......	......	......	......	......	......
ESE	−3.8	− 6.3	− 9.5	− 6.7	− 8.4	− 5.1	0	......	......	......	......	......
SE	−4.3	− 5.0	− 5.4	− 5.6	− 2.3	......	......	......	......	......	......	......
SSE	−4.9	− 4.0	− 4.5	0.1	3.2	7.6	9.7	10.8	......	......	......	......
S	−4.2	− 1.8	0	3.0	3.7	6.4	8.9	10.9	15.3	22.2	......	......
SSW	−2.5	0.7	5.1	7.6	10.1	12.4	14.9	18.4	21.2	24.0	25.2	24.7
SW	0.5	5.6	11.2	13.7	15.9	19.3	20.8	24.3	25.4	25.5	......	......
WSW	2.9	9.2	15.6	14.8	15.4	16.5	16.0	16.9	16.0	20.0	26.2	27.6
W	8.3	11.5	14.2	14.7	12.8	15.9	15.4	18.2	18.9	21.4	22.7	24.6
WNW	8.8	11.5	14.0	14.0	14.5	15.5	15.8	18.9	19.5	22.4	22.7	29.0
NW	10.0	10.3	11.6	12.0	12.0	12.6	16.2	16.9	15.2	16.3	9.5	7.5
NNW	7.4	7.3	6.0	6.9	8.0	8.5	9.6	9.5	11.1	11.6	11.2	10.7
Means	2.9	4.9	7.0	8.6	9.8	12.1	13.9	16.2	17.8	20.4	19.7	19.8

SUMMER.

N	4.1	2.0	0	− 0.8	− 1.6	− 1.4	0.2	0	− 5.6	− 6.1	......	......
NNE	3.6	0	− 5.0	− 3.2	− 2.8	− 3.0	− 3.0	− 5.8	......	......	......	......
NE	......	......	......	......	......	......	......	......	......	......	......	......
ENE	−2.7	− 7.9	− 9.4	− 9.6	......	......	......	......	......	......	......	......
E	−5.6	− 6.6	− 7.7	− 8.8	−10.9	......	......	......	......	......	......	......
ESE	−5.5	− 7.3	− 8.1	− 8.5	− 8.4	−10.0	−12.9	14.0	......	......	......	......
SE	−4.6	− 6.2	− 7.0	− 4.8	− 0.9	......	......	......	......	......	......	......
SSE	−5.1	− 4.9	− 3.8	− 2.5	0.5	2.5	2.3	4.5	......	......	......	......
S	−2.3	0	0	1.6	2.3	5.6	6.9	9.6	18.5	20.8	......	......
SSW	−1.0	2.0	4.9	5.2	5.6	7.0	9.2	11.2	9.7	9.4	......	......
SW	−1.2	4.8	8.0	10.9	13.8	17.1	18.0	18.6	19.9	18.6	......	......
WSW	6.3	10.5	9.9	11.0	11.6	10.1	12.1	18.9	20.3	21.4	......	......
W	6.3	9.8	13.4	14.9	16.1	18.3	19.0	21.2	23.7	24.5	28.8	......
WNW	7.0	9.4	11.3	11.2	11.0	12.2	13.2	14.6	18.0	22.2	26.6	26.4
NW	6.4	7.4	8.2	8.9	8.5	10.0	11.2	13.5	15.7	19.4	20.9	25.7
NNW	4.3	4.3	4.2	4.4	4.0	4.1	4.6	4.8	8.0	8.6	− 9.4	......
Means	2.8	3.8	4.7	5.7	6.5	8.4	10.2	12.4	16.7	18.4	22.3	26.0

TABLE XXV.—*West components of winds at each level*—Concluded.

AUTUMN.

Wind direction at 1,000 m.	Altitude, meters. 526 (surface).	750	1,000	1,250	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000
N	5.8	5.1	0	1.4	1.5	0	0	......	......	......	......	......
NNE	2.1	0	−4.0	−3.9	−3.9	−3.6	−3.9	−5.2	0	......	......	......
NE	1.6	0	−4.0	−4.5	−5.0	−3.4	−3.7	0	0	......	......	......
ENE	......	......	......	......	......	......	......	......	......	......	......	......
E	......	......	......	......	......	......	......	......	......	......	......	......
ESE	−5.2	−7.2	−6.6	−6.1	......	......	......	......	......	......	......	......
SE	−6.4	−6.8	−7.0	−4.1	−1.6	......	......	......	......	......	......	......
SSE	−5.2	−4.5	−5.1	−0.3	2.4	9.3	13.3	15.6	17.9	21.2	19.9	16.6
S	−4.9	−2.3	0	5.0	7.2	9.8	13.5	11.1	17.4	19.9	......	......
SSW	−3.4	0.8	5.9	7.2	8.7	9.7	13.4	16.4	20.5	19.1	16.2	16.8
SW	−0.1	3.5	10.2	12.7	13.8	15.2	14.5	17.8	17.8	19.5	21.1	......
WSW	2.9	9.0	13.8	17.1	19.8	25.0	22.6	20.0	20.6	......	......	......
W	8.4	13.5	18.8	20.8	21.3	20.5	21.2	28.3	......	......	......	......
WNW	10.3	12.3	14.0	13.6	13.4	13.0	16.2	17.9	17.1	21.0	21.4	19.4
NW	8.7	9.8	11.2	11.0	11.4	12.6	13.4	12.6	16.4	18.4	19.7	......
NNW	5.9	4.7	4.4	5.8	7.7	6.4	5.8	10.7	12.4	12.3	18.8	20.1
Means	3.7	5.6	7.3	8.8	10.3	12.0	13.0	14.9	16.3	19.1	19.9	18.2

WINTER.

Wind direction at 1,000 m.	526 (surface).	750	1,000	1,250	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000
N	7.4	5.8	0	18.2	20.6	......	......	......	......	......	......	......
NNE	6.7	0	−5.3	−4.6	−4.1	0	6.5	14.1	15.6	......	......	......
NE	6.7	0	−6.2	−6.6	−3.8	−3.8	6.1	13.9	15.6	22.0	......	......
ENE	......	......	......	......	......	......	......	......	......	......	......	......
E	−5.2	−8.4	−10.2	−7.4	−5.2	......	......	......	......	......	......	......
ESE	−4.5	−8.8	−11.0	−9.8	−8.4	......	......	......	......	......	......	......
SE	−5.8	−6.0	−6.6	−5.2	−5.0	−3.6	11.2	......	......	......	......	......
SSE	−3.3	−5.2	−5.1	−4.4	−4.2	−3.7	......	......	......	......	......	......
S	−5.6	−3.0	0	4.2	7.7	10.7	12.8	16.9	18.2	......	......	......
SSW	−1.7	3.3	5.4	7.8	9.8	12.0	13.6	16.9	14.8	14.8	15.2	14.4
SW	−1.6	4.6	8.7	10.6	12.7	17.8	22.4	27.9	27.4	......	......	......
WSW	0.7	8.5	14.0	14.8	17.3	20.2	23.7	26.6	......	......	......	......
W	7.3	12.5	16.9	19.4	21.7	25.2	27.0	26.1	20.2	21.8	26.0	31.8
WNW	11.3	14.5	17.0	16.9	16.9	18.3	18.3	16.8	17.8	21.0	23.2	31.2
NW	9.5	10.6	12.0	12.3	11.2	13.2	16.9	21.7	20.0	23.0	19.5	......
NNW	7.9	6.6	6.3	8.2	5.2	12.5	16.0	15.8	......	......	......	......
Means	4.6	7.5	9.9	11.4	12.4	15.4	17.8	19.9	17.7	19.8	20.4	25.8

YEAR.

Wind direction at 1,000 m.	526 (surface).	750	1,000	1,250	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000
N	5.5	2.7	0	1.9	2.1	−0.8	0.1	0	−5.6	−6.1	......	......
NNE	3.9	0	−4.9	−3.6	−3.2	−2.5	−1.3	−0.7	7.8	......	......	......
NE	4.2	0	−5.1	−5.6	−4.4	−3.6	1.2	7.0	7.8	22.0	......	......
ENE	−2.7	−7.9	−9.4	−9.6	......	......	......	......	......	......	......	......
E	−5.5	−8.1	−10.4	−8.8	−7.3	−3.5	......	......	......	......	......	......
ESE	−5.1	−7.4	−8.6	−8.1	−8.4	−8.8	−6.4	14.0	......	......	......	......
SE	−5.1	−5.9	−6.5	−4.6	−2.5	−3.6	11.2	......	......	......	......	......
SSE	−5.0	−4.5	−4.5	−1.0	1.9	6.3	9.7	11.3	17.9	21.2	19.9	16.6
S	−4.4	−1.9	0	3.4	5.0	8.0	10.4	12.7	16.7	21.1	......	......
SSW	−2.2	1.7	5.3	7.4	9.4	11.4	13.6	16.7	18.0	19.3	19.9	19.5
SW	−0.6	4.6	9.5	12.0	14.0	17.4	19.1	22.1	21.0	21.0	21.1	......
WSW	2.5	9.0	14.2	15.2	16.9	19.1	18.1	19.7	18.0	20.6	26.2	27.6
W	7.6	11.7	15.3	16.8	17.3	19.9	20.5	21.5	20.3	21.8	24.5	26.4
WNW	9.5	12.1	14.3	14.1	14.2	15.2	15.9	17.2	18.2	21.9	23.9	25.3
NW	8.5	9.4	10.5	10.8	10.6	12.0	13.9	15.9	16.2	18.9	17.4	19.6
NNW	5.9	5.4	5.0	5.9	6.2	6.6	7.6	9.0	11.1	11.1	9.0	12.6
Means	3.5	5.4	7.2	8.6	9.8	12.2	13.8	15.8	17.2	19.6	20.4	21.1

TABLE XXVI.—*North components of winds at each level.*

Wind direction at 1,000 m.	Altitude, meters. 526 (surface).	750	1,000	1,250	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000
SPRING.												
N	7.2	9.6	9.0	6.4	3.9	......	......	......	......	......	......	......
NNE	......	......	......	......	......	......	......	......	......	......	......	......
NE	......	......	......	......	......	......	......	......	......	......	......	......
ENE	......	......	......	......	......	......	......	......	......	......	......	......
E	0	0	0	−11.5	−10.3	− 8.4	......	......	......	......	......	......
ESE	0	− 2.7	− 4.0	− 6.7	− 8.4	−12.4	−15.9	......	......	......	......	......
SE	−3.4	− 5.0	− 5.4	− 5.2	− 2.3	......	......	......	......	......	......	......
SSE	−6.4	− 9.2	−11.0	−12.6	−13.1	−11.1	−12.0	−14.6	......	......	......	......
S	−6.1	−11.3	−13.8	−12.3	−12.3	−12.7	−13.3	−12.1	−10.1	− 8.7	......	......
SSW	−6.3	−11.5	−13.0	−11.7	−10.5	−10.3	− 7.7	− 5.5	− 7.0	0.7	5.1	10.2
SW	−5.5	− 9.8	−11.2	−11.3	− 9.4	− 6.9	− 7.6	− 5.2	− 6.6	5.8	......	......
WSW	−3.1	− 7.0	− 6.5	− 7.2	− 6.7	− 5.8	− 5.4	− 5.8	− 3.7	− 1.5	0	0
W	1.5	1.4	0	− 1.2	0	0.2	− 1.2	− 1.3	− 2.0	− 2.8	− 2.5	0
WNW	3.1	4.7	5.8	6.5	6.9	6.8	7.6	7.6	6.0	7.3	6.1	0
NW	6.7	9.7	11.6	12.0	12.0	11.6	13.3	12.2	11.5	8.2	8.8	18.0
NNW	4.9	10.0	14.6	14.5	13.3	11.9	10.9	13.5	15.4	17.2	17.6	21.0
Means	−0.6	− 1.7	− 1.9	− 1.9	− 1.4	− 0.8	− 0.7	0.5	1.2	3.7	6.3	9.4
SUMMER.												
N	3.4	8.5	10.8	9.9	9.1	11.2	12.2	14.6	13.6	14.7	......	......
NNE	4.8	10.6	12.1	11.0	9.7	10.9	11.4	14.1	......	......	......	......
NE	......	......	......	......	......	......	......	......	......	......	......	......
ENE	2.4	3.3	3.9	4.0	......	......	......	......	......	......	......	......
E	0	0	0	0	0	......	......	......	......	......	......	......
ESE	−0.4	− 2.3	− 3.4	− 4.7	− 4.4	− 4.7	−12.9	−14.0	......	......	......	......
SE	−4.6	− 6.2	− 7.0	− 8.8	− 9.2	......	......	......	......	......	......	......
SSE	−4.6	− 8.6	− 9.3	− 8.5	− 8.1	− 9.8	−11.2	−10.9	......	......	......	......
S	−6.7	−10.8	−12.9	−11.0	−10.1	−10.8	−11.6	−13.9	−12.6	− 9.6	......	......
SSW	−6.3	− 9.8	−11.9	−12.4	−13.4	−14.4	−13.2	−13.1	−23.4	−22.7	......	......
SW	−4.9	− 8.9	− 8.0	− 7.2	− 9.6	− 6.8	− 6.6	− 2.6	− 3.0	−13.5	......	......
WSW	−2.6	− 4.4	− 4.1	− 2.4	− 2.4	− 2.0	− 2.6	− 6.0	− 8.4	− 8.9	......	......
W	0.4	− 0.3	0	0.9	1.0	2.4	1.1	1.5	5.0	−10.1	−11.7	......
WNW	1.6	3.8	4.7	6.1	7.2	8.0	7.2	7.5	7.9	4.6	4.1	5.3
NW	3.9	6.8	8.2	8.8	8.9	9.1	8.5	6.7	8.4	7.3	8.7	10.6
NNW	4.4	8.2	10.1	10.1	9.4	9.6	10.5	13.3	10.8	13.5	22.6	......
Means	0.6	1.3	1.8	2.8	3.4	4.2	4.3	3.9	3.3	1.0	5.4	8.0
AUTUMN.												
N	5.8	12.3	14.0	10.5	9.4	10.6	10.2	......	......	......	......	......
NNE	5.0	10.9	9.6	9.4	9.3	8.6	9.3	12.6	12.7	......	......	......
NE	1.6	4.0	4.0	4.5	5.0	8.1	9.0	12.0	12.3	......	......	......
ENE	......	......	......	......	......	......	......	......	......	......	......	......
E	......	......	......	......	......	......	......	......	......	......	......	......
ESE	1.0	0	− 2.7	− 2.5	......	......	......	......	......	......	......	......
SE	−1.0	− 5.3	− 7.0	− 7.2	− 6.6	......	......	......	......	......	......	......
SSE	−5.4	−10.0	−12.4	−13.5	−14.1	− 7.4	− 2.4	0.6	− 0.3	0.6	− 8.2	− 6.9
S	−6.4	−10.2	−12.6	−10.5	− 8.3	− 8.5	−10.1	− 9.9	− 7.2	− 8.2	......	......
SSW	−7.6	−12.4	−14.2	−13.6	−12.3	−10.5	−11.6	− 9.9	−12.7	−14.0	−16.2	−16.8
SW	−6.0	− 9.1	−10.2	− 8.8	− 5.2	− 2.0	− 2.0	− 1.6	− 2.8	4.6	5.1	......
WSW	−4.3	− 4.8	− 5.7	− 3.8	− 2.2	− 2.1	2.5	0	0	......	......	......
W	−1.8	0	0	0	0	13.2	8.8	11.7	......	......	......	......
WNW	4.0	4.9	5.8	6.2	7.0	6.9	5.7	3.2	4.2	1.8	2.4	0
NW	6.0	9.3	11.2	10.7	11.0	10.3	10.2	8.1	8.8	6.6	10.6	......
NNW	5.6	9.3	10.7	10.7	10.7	9.6	11.6	14.5	18.1	17.1	18.8	20.1
Means	0.7	1.1	1.2	1.2	2.0	3.6	4.1	2.8	3.1	1.3	3.5	− 3.4

TABLE XXVI.—*North components of winds at each level.*—Concluded.

WINTER.

Wind direction at 1,000 m.	Altitude, meters.											
	526 (surface).	750	1,000	1,250	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000
N	3.1	14.0	21.9	18.2	20.6	......	......	......	......	......	......	......
NNE	2.8	10.9	12.8	11.2	9.9	11.8	15.8	14.1	15.6	......	......	......
NE	2.8	7.7	6.2	6.6	9.1	9.1	14.7	13.9	15.6	9.1	......	......
ENE	......	......	......	......	......	......	......	......	......	......	......	......
E	0.8	0	0	0	0	......	......	......	......	......	......	......
ESE	0	− 3.7	− 4.6	− 4.0	− 3.5	......	......	......	......	......	......	......
SE	−1.3	− 4.2	− 6.6	− 7.4	− 7.2	− 8.6	−11.2	......	......	......	......	......
SSE	−1.4	− 5.2	−12.3	−10.6	−10.1	− 9.0	......	......	......	......	......	......
S	−6.7	−13.2	−15.9	−15.5	−14.3	−15.2	−14.7	−14.8	−18.2	......	......	......
SSW	−6.7	−11.0	−13.1	−12.1	−10.8	− 7.5	− 7.8	− 9.8	−14.5	−11.5	−10.6	−14.4
SW	−4.6	− 8.2	− 8.7	− 8.4	− 7.6	− 2.1	− 2.5	− 3.4	−11.3	......	......	......
WSW	−3.4	− 5.8	− 5.8	− 5.7	− 5.4	0.3	0	0	......	......	......	......
W	1.5	0	0	3.0	4.5	1.2	1.7	1.5	5.0	1.4	− 4.6	0
WNW	4.5	6.0	7.0	8.0	8.1	5.5	4.0	2.3	3.2	1.8	9.5	0
NW	6.0	10.6	12.0	10.8	10.0	8.9	7.9	8.9	11.2	12.8	19.5	......
NNW	5.1	12.8	15.3	13.2	13.4	19.0	16.0	15.8	......	......	......	......
Means	0.5	− 0.1	− 0.1	0.4	0.8	0.1	− 0.8	− 1.4	− 3.4	0.8	− 0.3	− 4.8

YEAR.

Wind direction at 1,000 m.	526 (surface).	750	1,000	1,250	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000
N	5.2	10.3	11.9	10.2	9.9	11.0	11.4	14.6	13.6	14.7	......	......
NNE	4.5	10.7	11.8	10.8	9.7	10.6	11.8	13.7	14.2	......	......	......
NE	2.2	5.8	5.1	5.6	7.0	8.6	11.8	13.0	14.0	9.1	......	......
ENE	2.4	3.3	3.9	4.0	......	......	......	......	......	......	......	......
E	0.3	0	0	− 2.3	− 2.1	− 8.4	......	......	......	......	......	......
ESE	−0.1	− 2.2	− 3.6	− 4.8	− 4.8	− 6.6	−14.4	−14.0	......	......	......	......
SE	−2.9	− 5.3	− 6.5	− 7.0	− 6.9	− 8.6	−11.2	......	......	......	......	......
SSE	−5.4	− 9.1	−10.8	−11.4	−11.8	− 9.8	− 9.3	− 9.3	− 0.3	0.6	− 8.2	− 6.9
S	−6.4	−11.5	−14.0	−12.7	−12.1	−12.8	−13.2	−12.9	−11.8	− 8.7	......	......
SSW	−6.6	−11.3	−13.1	−12.2	−11.1	− 9.8	− 8.9	− 8.8	−11.9	− 7.6	− 4.9	− 5.5
SW	−5.2	− 8.9	− 9.5	− 9.0	− 7.7	− 4.1	− 4.7	− 3.2	− 4.4	− 0.2	5.1	......
WSW	−3.5	− 5.8	− 5.9	− 5.5	− 4.7	− 2.9	− 2.7	− 3.8	− 3.9	− 4.5	0	0
W	1.2	0.5	0	0.8	1.9	1.6	0.6	0.7	0.8	− 2.7	− 4.4	0
WNW	3.4	4.9	5.9	6.8	7.4	6.7	6.3	5.7	5.5	4.7	4.9	1.8
NW	5.5	8.9	10.5	10.5	10.4	10.1	10.0	8.9	9.7	8.1	10.4	13.1
NNW	5.0	9.5	12.0	11.8	11.3	10.9	11.4	13.9	15.7	16.3	18.7	20.9
Means	0.2	0	0.1	0.4	0.9	1.3	1.3	1.3	1.5	2.1	4.4	4.6

TABLE XXVII.—*Resultant air movement at each level.*

SPRING.

Wind direction at 1,000 m.	526 m. (surface).			750 m.			1,000 m.			1,250 m.			1,500 m.			2,000 m.		
	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.
			m.p.s.			*m.p.s.*			*m.p.s.*			*m.p.s.*			*m.p.s.*			*m.p.s.*
N.	4	N. 41° W.	9.5	4	N. 5° W.	9.6	4	N.	9.0	2	N.	6.4	1	N.	3.9			
NNE.																		
NE.																		
ENE.																		
E.	1	E.	5.8	1	E.	10.8	1	E.	16.3	1	S. 45° E.	16.2	1	S. 22° E.	11.1	1	S. 22° E.	9.1
ESE.	2	E.	3.8	2	S. 67° E.	6.9	2	S. 68° E.	10.3	2	S. 45° E.	9.5	1	S. 45° E.	11.9	1	S. 22° E.	13.4
SE.	4	S. 51° E.	5.5	4	S. 45° E.	7.1	4	S. 45° E.	7.6	4	S. 41° E.	6.9	1	S. 45° E.	3.2			
SSE.	12	S. 37° E.	8.1	12	S. 23° E.	10.0	12	S. 22° E.	11.9	12	S. 1° W.	12.6	11	S. 14° W.	13.5	10	S. 34° W.	13.5
S.	34	S. 34° E.	7.4	33	S. 9° E.	11.4	33	S.	13.8	33	S. 14° W.	12.6	31	S. 17° W.	12.8	25	S. 27° W.	14.2
SSW.	18	S. 22° E.	6.8	18	S. 3° W.	11.5	18	S. 22° W.	14.0	18	S. 33° W.	14.0	18	S. 44° W.	14.6	17	S. 50° W.	16.1
SW.	7	S. 6° W.	5.5	7	S. 30° W.	11.3	7	S. 45° W.	15.8	7	S. 51° W.	17.7	7	S. 59° W.	18.5	7	S. 70° W.	20.5
WSW.	9	S. 43° W.	4.2	9	S. 53° W.	11.6	9	S. 68° W.	16.9	9	S. 64° W.	16.5	9	S. 67° W.	16.8	9	S. 71° W.	17.5
W.	17	N. 80° W.	8.4	17	N. 83° W.	11.6	17	W.	14.2	17	S. 85° W.	14.8	15	W.	12.8	15	N. 89° W.	15.9
WNW.	28	N. 71° W.	9.3	27	N. 68° W.	12.4	28	N. 68° W.	15.2	28	N. 65° W.	15.4	28	N. 65° W.	16.1	28	N. 66° W.	16.9
NW.	27	N. 56° W.	12.0	27	N. 47° W.	14.1	27	N. 45° W.	16.4	26	N. 45° W.	17.0	26	N. 45° W.	17.0	26	N. 47° W.	17.1
NNW.	10	N. 56° W.	8.9	10	N. 36° W.	12.4	10	N. 22° W.	15.8	10	N. 25° W.	16.1	10	N. 31° W.	15.5	10	N. 35° W.	14.6
Seasonal mean.	173	S. 78° W.	3.0	171	S. 71° W.	5.2	172	S. 75° W.	7.3	169	S. 77° W.	8.9	159	S. 81° W.	9.9	149	S. 86° W.	12.1

TABLE XXVII.—*Resultant air movement at each level*—Continued.

SPRING—Continued.

Wind direction at 1,000 m.	2,500 m.			3,000 m.			3,500 m.			4,000 m.			4,500 m.			5,000 m.		
	Observations.	Wind.		Observations.	Wind.		Observations.	Wind.		Observations.	Wind.		Observations.	Wind.		Observations.	Wind.	
		Direction.	Velocity.		Direction.	Velocity.		Direction.	Velocity.		Direction.	Velocity.		Direction.	Velocity.		Direction.	Velocity.
			m.p.s.			*m.p.s.*			*m.p.s.*			*m.p.s.*			*m.p.s.*			*m.p.s.*
N.																		
NNE.																		
NE.																		
ENE.																		
E.																		
ESE.	1	S.	15.9															
SE.																		
SSE.	9	S. 39° W.	15.4	7	S. 37° W.	18.2												
S.	20	S. 34° W.	16.0	13	S. 42° W.	16.3	8	S. 56° W.	18.3	4	S. 69° W.	23.9						
SSW.	13	S. 63° W.	16.8	9	S. 73° W.	19.2	9	S. 72° W.	22.3	6	N. 88° W.	24.0	4	N. 79° W.	25.7	2	N. 66° W.	26.7
SW.	7	S. 70° W.	22.1	5	S. 78° W.	24.9	4	S. 75° W.	26.2	2	N. 77° W.	26.2						
WSW.	9	S. 71° W.	16.9	7	S. 71° W.	17.9	5	S. 77° W.	16.4	3	S. 86° W.	20.0	2	W.	26.2	2	W.	27.6
W.	14	S. 86° W.	15.5	10	S. 86° W.	18.2	9	S. 84° W.	19.0	7	S. 83° W.	21.6	4	S. 84° W.	22.8	3	W.	24.6
WNW.	25	N. 64° W.	17.5	22	N. 68° W.	20.4	14	N. 73° W.	20.4	10	N. 72° W.	23.6	6	N. 75° W.	23.5	1	W.	29.0
NW.	18	N. 51° W.	21.0	14	N. 54° W.	20.8	9	N. 53° W.	19.1	5	N. 63° W.	18.2	3	N. 47° W.	13.0	1	N. 22° W.	19.5
NNW.	9	N. 41° W.	14.5	7	N. 35° W.	16.5	6	N. 36° W.	19.0	5	N. 34° W.	20.7	4	N. 32° W.	20.9	4	N. 27° W.	23.6
Seasonal mean.	125	S. 87° W.	13.9	94	N. 88° W.	16.2	64	N. 86° W.	17.8	42	N. 80° W.	20.7	23	N. 72° W.	20.7	13	N. 65° W.	21.9

TABLE XXVII.—*Resultant air movement at each level*—Continued.

SUMMER.

Wind direction at 1,000 m.	526 m. (surface).			750 m.			1,000 m.			1,250 m.			1,500 m.			2,000 m.		
	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.
			m.p.s.			*m.p.s.*			*m.p.s.*			*m.p.s.*			*m.p.s.*			*m.p.s.*
N.	4	N. 51° W.	5.3	4	N. 13° W.	8.7	4	N.	10.8	4	N. 5° E.	9.9	4	N. 10° E.	9.2	3	N. 7° E.	11.3
NNE.	4	N. 37° W.	6.0	4	N.	10.6	4	N. 22° E.	13.1	4	N. 16° E.	11.4	4	N. 16° E.	10.1	3	N. 16° E.	11.3
NE.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
ENE.	2	N. 49° E.	3.6	1	N. 68° E.	8.5	1	N. 68° E.	10.2	2	N. 68° E.	10.4	...	...	...	...	...	...
E.	2	E.	5.6	2	E.	6.6	2	E.	7.7	2	E.	8.8	2	E.	10.9	...	...	...
ESE.	7	S. 85° E.	5.5	7	S. 73° E.	7.6	6	S. 68° E.	8.8	3	S. 61° E.	9.7	3	S. 62° E.	9.5	3	S. 65° E.	11.0
SE.	4	S. 45° E.	6.5	4	S. 45° E.	8.8	4	S. 45° E.	9.9	3	S. 29° E.	10.0	2	S. 6° E.	9.2	...	...	...
SSE.	12	S. 48° E.	6.9	12	S. 30° E.	9.9	12	S. 22° E.	10.0	12	S. 16° E.	8.9	9	S. 4° W.	8.1	5	S. 14° W.	10.1
S.	9	S. 19° E.	7.1	9	S.	10.8	9	S.	12.9	7	S. 8° W.	11.1	7	S. 13° W.	10.3	4	S. 27° W.	12.2
SSW.	4	S. 9° E.	7.1	4	S. 12° W.	10.0	4	S. 22° W.	12.9	4	S. 22° W.	13.4	4	S. 22° W.	14.5	4	S. 26° W.	16.0
SW.	6	S. 14° E.	5.0	6	S. 28° W.	10.1	6	S. 45° W.	11.3	5	S. 57° W.	13.1	4	S. 55° W.	16.8	4	S. 68° W.	18.4
WSW.	2	S. 68° W.	6.8	2	S. 68° W.	11.4	2	S. 68° W.	10.7	2	S. 77° W.	11.3	2	S. 78° W.	11.8	2	S. 79° W.	10.3
W.	7	N. 87° W.	6.3	7	S. 88° W.	9.8	7	W.	13.4	7	N. 87° W.	14.9	7	N. 87° W.	16.1	6	N. 83° W.	18.5
WNW.	26	N. 77° W.	7.2	25	N. 68° W.	10.1	25	N. 68° W.	12.2	25	N. 62° W.	12.8	24	N. 57° W.	13.1	19	N. 57° W.	14.6
NW.	33	N. 59° W.	7.5	32	N. 48° W.	10.0	32	N. 45° W.	11.6	32	N. 45° W.	12.5	33	N. 44° W.	12.3	25	N. 48° W.	13.5
NNW.	15	N. 44° W.	6.1	15	N. 28° W.	9.3	15	N. 22° W.	11.0	13	N. 23° W.	11.0	13	N. 23° W.	10.2	11	N. 23° W.	10.4
Seasonal mean.	137	N. 78° W.	2.8	134	N. 72° W.	4.0	133	N. 68° W.	5.0	125	N. 64° W.	6.4	118	N. 62° W.	7.3	89	N. 64° W.	9.4

TABLE XXVII.—*Resultant air movement at each level*—Continued.

SUMMER—Continued.

Wind direction at 1,000 m.	2,500 m.			3,000 m.			3,500 m.			4,000 m.			4,500 m.			5,000 m.		
	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.
			m.p.s.			*m.p.s.*			*m.p.s.*			*m.p.s.*			*m.p.s.*			*m.p.s.*
N	3	N. 1° W.	12.2	3	N.	14.6	1	N. 22° E.	14.7	1	N. 22° E.	14.7						
NNE	3	N. 15° E.	11.8	2	N. 22° E.	15.2												
NE																		
ENE																		
E																		
ESE	1	S. 45° E.	18.3	1	S. 45° W.	19.8												
SE																		
SSE	2	S. 12° W.	11.4	2	S. 22° W.	11.8												
S	4	S. 31° W.	13.5	3	S. 35° W.	16.9	2	S. 56° W.	22.4	2	S. 65° W.	22.9						
SSW	4	S. 35° W.	16.1	3	S. 40° W.	17.2	2	S. 22° W.	25.3	1	S. 22° W.	24.6						
SW	4	S. 70° W.	19.2	4	S. 82° W.	18.8	4	S. 81° W.	20.1	2	S. 54° W.	23.0						
WSW	2	S. 78° W.	12.4	2	S. 72° W.	19.8	2	S. 68° W.	22.0	2	S. 68° W.	23.2						
W	6	N. 87° W.	19 0	6	N. 86° W.	21.3	4	N. 78° W.	24.2	1	S. 68° W.	26.5	1	S. 68° W.	30.6			
WNW	19	N. 61° W.	15.0	16	N. 63° W.	16.4	10	N. 66° W.	19.7	8	N. 78° W.	22.7	7	N. 81° W.	26.9	2	N. 79° W.	26.9
NW	25	N. 53° W.	14.1	17	N. 64° W.	15.1	11	N. 62° W.	17.8	6	N. 69° W.	20.7	3	N. 68° W.	22.6	2	N. 68° W.	27.8
NNW	8	N. 24° W.	11.5	6	N. 20° W.	14.1	2	N. 36° W.	13.4	2	N. 32° W.	16.0	1	N. 22° E.	24.5			
Seasonal mean	81	N. 68° W.	11.1	65	N. 72° W.	13.0	38	N. 79° W.	17.0	25	N. 87° W.	18.7	12	N. 76° W.	23.0	4	N. 73° W.	27.2

TABLE XXVII.—*Resultant air movement at each level*—Continued.

AUTUMN.

Wind direction at 1,000 m.	526 m. (surface).			750 m.			1,000 m.			1,250 m.			1,500 m.			2,000 m		
	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.
			m.p.s.			*m.p.s.*			*m.p.s.*			*m.p.s.*			*m.p.s.*			*m.p.s.*
N.	3	N. 45° W.	8.2	3	N. 22° W.	13.3	3	N.	14.0	3	N. 8° W.	10.6	3	N. 9° W.	9.5	2	N.	10.6
NNE	1	N. 22° W.	5.4	1	N.	10.9	1	N. 22° E.	10.4	1	N. 22° E.	10.2	1	N. 22° E.	10.1	1	N. 22° E.	9.3
NE	1	N. 45° W.	2.2	1	N.	4.0	1	N. 45° E.	5.7	1	N. 45° E.	6.4	1	N. 45° E.	7.1	1	N. 22° E.	8.8
ENE	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
E	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
ESE	2	N. 79° E.	5.3	2	E.	7.2	2	S. 68° E.	7.1	1	S. 68° E.	6.6	......	......	......	......	......	......
SE	3	S. 81° E.	6.5	3	S. 52° E.	8.6	3	S. 45° E.	9.9	3	S. 30° E.	8.3	2	S. 13° E.	6.8	......	......	......
SSE	10	S. 44° E.	7.5	9	S. 24° E.	11.0	9	S. 22° E.	13.4	10	S. 1° E.	13.5	9	S. 10° W.	14.3	5	S. 52° W.	11.9
S	11	S. 37° E.	8.1	10	S. 13° E.	10.4	10	S.	12.6	9	S. 25° W.	11.6	8	S. 41° W.	11.0	6	S. 49° W.	13.0
SSW	6	S. 25° E.	8.3	6	S. 34° E.	12.4	6	S. 22° W.	15.4	6	S. 28° W.	15.4	6	S. 35° W.	15.1	6	S. 43° W.	14.3
SW	8	S. 1° E.	6.0	8	S. 21° W.	9.7	8	S. 45° W.	14.4	8	S. 55° W.	15.4	8	S. 70° W.	14.7	7	S. 83° W.	15.3
WSW	8	S. 34° W.	5.2	8	S. 62° W.	10.2	8	S. 68° W.	14.9	7	S. 78° W.	17.5	7	S. 89° W.	19.9	6	S. 85° W.	25.1
W	2	S. 78° W.	8.6	2	W.	13.5	2	W.	18.8	2	W.	20.8	2	W.	21.3	2	N. 57° W.	24.4
WNW	21	N. 69° W.	11.0	21	N. 68° W.	13.2	21	N. 68° W.	15.2	21	N. 65° W.	14.9	20	N. 62° W.	15.1	19	N. 62° W.	14.7
NW	28	N. 55° W.	10.6	27	N. 46° W.	13.5	27	N. 45° W.	15.8	26	N. 46° W.	15.3	23	N. 46° W.	15.8	19	N. 51° W.	16.3
NNW	12	N. 47° W.	8.1	12	N. 27° W.	10.4	12	N. 22° W.	11.6	10	N. 29° W.	12.2	9	N. 36° W.	13.2	9	N. 34° W.	11.5
Seasonal mean	116	N. 79° W.	3.7	113	N. 79° W.	5.7	113	N. 81° W.	7.4	108	N. 82° W.	8.9	99	N. 79° W.	10.5	83	N. 73° W.	12.5

TABLE XXVII.—*Resultant air movement at each level*—Continued.

AUTUMN—Continued.

Wind direction at 1,000 m.	2,500 m.			3,000 m.			3,500 m.			4,000 m.			4,500 m.			5,000 m.		
	Observations.	Wind.		Observations.	Wind.		Observations.	Wind.		Observations.	Wind.		Observations.	Wind.		Observations.	Wind.	
		Direction.	Velocity.		Direction.	Velocity.		Direction.	Velocity.		Direction.	Velocity.		Direction.	Velocity.		Direction.	Velocity.
			m.p.s.			*m.p.s.*			*m.p.s.*			*m.p.s.*			*m.p.s.*			*m.p.s.*
N.	2	N.	10.2															
NNE	1	N. 22° E.	10.1	1	N. 22° E.	13.6	1	N.	12.7									
NE	1	N. 22° E.	9.7	1	N.	12.0	1	N.	12.3									
ENE																		
E																		
ESE																		
SE																		
SSE	4	S. 80° W.	13.5	4	N. 88° W.	15.6	4	S. 89° W.	17.9	2	N. 88° W.	21.2	1	S. 68° W.	21.5	1	S. 68° W.	18.0
S	5	S. 53° W.	16.9	3	S. 48° W.	14.9	3	S. 68° W.	18.8	3	S. 68° W.	21.5						
SSW	5	S. 49° W.	17.7	5	S. 59° W.	19.2	4	S. 58° W.	24.1	3	S. 54° W.	23.7	2	S. 45° W.	22.9	2	S. 45° W.	23.8
SW	6	S. 82° W.	14.6	6	S. 85° W.	17.9	6	S. 81° W.	18.0	3	N. 77° W.	20.0	3	N. 76° W.	21.7			
WSW	3	N. 84° W.	22.7	2	W.	20.0	2	W.	20.6									
W	1	N. 68° W.	22.9	1	N. 68° W.	30.6												
WNW	15	N. 71° W.	17.2	13	N. 80° W.	18.2	11	N. 76° W.	17.6	5	N. 85° W.	21.1	4	N. 84° W.	21.5	2	W.	19.4
NW	18	N. 53° W.	16.8	10	N. 57° W.	15.0	8	N. 62° W.	18.6	6	N. 70° W.	19.5	5	N. 62° W.	22.4			
NNW	7	N. 27° W.	13.0	5	N. 36° W.	18.0	5	N. 34° W.	21.9	2	N. 36° W.	21.1	1	N. 45° W.	26.6	1	N. 45° W.	28.4
Seasonal mean	68	N. 73° W.	13.6	51	N. 79° W.	15.2	45	N. 79° W.	16.6	24	N. 86° W.	19.1	16	N. 80° W.	20.2	6	S. 79° W.	18.5

TABLE XXVII.—*Resultant air movement at each level*—Continued.

WINTER.

Wind direction at 1,000 m.	526 m. (surface). Observations.	526 m. (surface). Wind. Direction.	526 m. (surface). Wind. Velocity.	750 m. Observations.	750 m. Wind. Direction.	750 m. Wind. Velocity.	1,000 m. Observations.	1,000 m. Wind. Direction.	1,000 m. Wind. Velocity.	1,250 m. Observations.	1,250 m. Wind. Direction.	1,250 m. Wind. Velocity.	1,500 m. Observations.	1,500 m. Wind. Direction.	1,500 m. Wind. Velocity.	2,000 m. Observations.	2,000 m. Wind. Direction.	2,000 m. Wind. Velocity.
			m.p.s.			*m.p.s.*			*m.p.s.*			*m.p.s.*			*m.p.s.*			*m.p.s.*
N.	1	N. 68° W.	8.0	1	N. 22° W.	15.1	1	N.	21.9	1	N. 45° W.	25.7	1	N. 45° W.	29.2			
NNE.	1	N. 68° W.	7.2	1	N.	10.9	1	N. 22° E.	13.9	1	N. 22° E.	12.1	1	N. 22° E.	10.7	1	N.	11.8
NE.	1	N. 68° W.	7.2	1	N.	7.7	1	N. 45° E.	8.8	1	N. 45° E.	9.4	1	N. 22° E.	9.8	1	N. 22° E.	9.8
ENE.																		
E.	2	N. 82° E.	5.3	2	E.	8.4	2	E.	10.2	2	E.	7.4	2	E.	5.2			
ESE.	2	E.	4.5	2	S. 68° E.	9.5	2	S. 68° E.	11.9	2	S. 68° E.	10.6	2	S. 68° E.	9.1			
SE.	2	S. 77° E.	5.9	2	S. 55° E.	7.3	2	S. 45° E.	9.3	2	S. 35° E.	9.0	2	S. 35° E.	8.8	2	S. 22° E.	9.3
SSE.	1	S. 68° E.	3.6	1	S. 45° E.	7.4	1	S. 22° E.	13.3	1	S. 22° E.	11.5	1	S. 22° E.	10.9	1	S. 22° E.	9.7
S.	16	S. 40° E.	8.7	16	S. 13° E.	13.5	16	S.	15.9	16	S. 15° W.	16.1	16	S. 28° W.	16.2	15	S. 35° W.	18.6
SSW.	14	S. 69° E.	6.9	14	S. 17° W.	11.5	14	S. 22° W.	14.2	14	S. 33° W.	14.4	14	S. 42° W.	14.6	14	S. 58° W.	14.1
SW.	10	S. 19° E.	4.9	10	S. 29° W.	9.4	10	S. 45° W.	12.3	9	S. 52° W.	13.5	8	S. 59° W.	14.8	8	S. 83° W.	17.9
WSW.	8	S. 12° W.	3.5	8	S. 56° W.	10.3	8	S. 68° W.	15.2	7	S. 69° W.	15.9	7	S. 72° W.	18.1	6	N. 89° W.	20.2
W.	17	N. 78° W.	7.5	16	W.	12.5	16	W.	16.9	16	N. 78° W.	19.6	15	N. 78° W.	22.2	13	N. 87° W.	25.2
WNW.	36	N. 68° W.	12.2	33	N. 68° W.	15.7	33	N. 68° W.	18.4	31	N. 65° W.	18.7	31	N. 64° W.	18.7	28	N. 73° W.	19.1
NW.	20	N. 58° W.	11.2	20	N. 45° W.	15.0	20	N. 45° W.	17.0	20	N. 48° W.	16.4	20	N. 46° W.	15.0	17	N. 56° W.	15.9
NNW.	5	N. 57° W.	9.4	5	N. 27° W.	14.4	5	N. 22° W.	16.5	5	N. 32° W.	15.5	4	N. 21° W.	14.4	2	N. 33° W.	22.7
Seasonal mean.	136	N. 84° W.	4.6	132	W.	7.5	132	S. 89° W.	9.9	128	N. 88° W.	11.4	125	N. 86° W.	12.4	108	W.	15.4

TABLE XXVII.—*Resultant air movement at each level*—Continued.

WINTER—Continued.

Wind direction at 1,000 m.	2,500 m.			3,000 m.			3,500 m.			4,000 m.			4,500 m.			5,000 m.		
	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.	Observations.	Wind. Direction.	Wind. Velocity.
			m.p.s.			*m.p.s.*			*m.p.s.*			*m.p.s.*			*m.p.s.*			*m.p.s.*
N																		
NNE	1	N. 22° W.	17.1	1	N. 45° W.	20.0	1	N. 45° W.	22.0									
NE	1	N. 22° W.	15.9	1	N. 45° W.	19.7	1	N. 45° W.	22.0	1	N. 68° W.	23.8						
ENE																		
E																		
ESE																		
SE	1	S. 45° W.	15.8															
SSE																		
S	13	S. 41° W.	19.5	9	S. 49° W.	22.5	4	S. 45° W.	25.7									
SSW	14	S. 60° W.	15.7	12	S. 60° W.	19.5	7	S. 46° W.	20.7	4	S. 52° W.	18.7	3	S. 55° W.	18.5	1	S. 45° W.	20.4
SW	6	S. 84° W.	22.5	5	S. 83° W.	28.1	1	S. 68° W.	29.6									
WSW	3	W.	23.7	3	W.	26.6												
W	12	N. 86° W.	27.0	6	N. 87° W.	26.1	2	N. 76° W.	20.8	2	N. 86° W.	21.8	2	S. 80° W.	26.4	1	W.	31.8
WNW	19	N. 78° W.	18.7	11	N. 82° W.	17.0	7	N. 80° W.	18.1	4	N. 85° W.	21.1	2	N. 68° W.	25.1	1	W.	31.2
NW	13	N. 65° W.	18.7	10	N. 68° W.	23.5	3	N. 61° W.	22.9	3	N. 61° W.	26.3	1	N. 45° W.	27.6			
NNW	2	N. 45° W.	22.6	2	N. 45° W.	22.3												
Seasonal mean	85	S. 88° W.	17.8	60	S. 86° W.	19.9	26	S. 79° W.	18.0	14	N. 88° W.	19.8	8	S. 89° W.	20.4	3	S. 79° W.	26.2

TABLE XXVII.—*Resultant air movement at each level*—Continued.

YEAR

Wind direction at 1,000 m.	526 m. (surface). Observations.	526 m. Wind. Direction.	526 m. Wind. Velocity.	750 m. Observations.	750 m. Wind. Direction.	750 m. Wind. Velocity.	1,000 m. Observations.	1,000 m. Wind. Direction.	1,000 m. Wind. Velocity.	1,250 m. Observations.	1,250 m. Wind. Direction.	1,250 m. Wind. Velocity.	1,500 m. Observations.	1,500 m. Wind. Direction.	1,500 m. Wind. Velocity.	2,000 m. Observations.	2,000 m. Wind. Direction.	2,000 m. Wind. Velocity.
			m.p.s.			m.p.s.			m.p.s.			m.p.s.			m.p.s.			m.p.s.
N	12	N. 46° W.	7.6	12	N. 15° W.	10.6	12	N.	11.9	10	N. 11° W.	10.4	9	N. 12° W.	10.1	5	N. 37° E.	11.0
NNE	6	N. 41° W.	6.0	6	N.	10.7	6	N. 22° E.	12.8	6	N. 18° E.	11.4	6	N. 18° E.	10.2	5	N. 14° E.	10.9
NE	2	N. 62° W.	4.7	2	N.	5.8	2	N. 45° E.	7.2	2	N. 45° E.	7.9	2	N. 32° E.	8.3	2	N. 22° E.	9.8
ENE	2	N. 49° E.	3.6	1	N. 68° E.	8.5	1	N. 68° E.	10.2	2	N. 68° E.	10.4						
E	5	N. 87° E.	5.5	5	E.	8.1	5	E.	10.4	5	S. 75° E.	9.1	5	S. 74° E.	7.6	1	S. 22° E.	9.1
ESE	13	S. 89° E.	5.1	13	S. 73° E.	7.7	12	S. 68° E.	9.8	8	S. 59° E.	9.4	6	S. 60° E.	9.7	4	S. 53° E.	11.0
SE	18	S. 60° E.	5.9	13	S. 48° E.	7.9	13	S. 45° E.	9.2	12	S. 34° E.	8.4	7	S. 20° E.	7.3	2	S. 22° E.	9.3
SSE	35	S. 43° E.	7.4	34	S. 26° E.	10.1	34	S. 22° E.	11.7	35	S. 5° E.	11.4	30	S. 9° W.	12.0	21	S. 33° W.	11.6
S	70	S. 34° E.	7.8	68	S. 10° E.	11.6	68	S.	14.0	65	S. 15° W.	13.1	62	S. 22° W.	13.1	50	S. 32° W.	15.1
SSW	42	S. 19° E.	6.9	42	S. 9° W.	11.4	42	S. 22° W.	14.1	42	S. 31° W.	14.3	42	S. 40° W.	14.5	41	S. 49° W.	15.0
SW	31	S. 7° E.	5.2	31	S. 27° W.	10.0	31	S. 45° W.	13.4	29	S. 53° W.	15.0	27	S. 61° W.	16.0	26	S. 77° W.	17.9
WSW	27	S. 36° W.	4.2	27	S. 57° W.	10.7	27	S. 68° W.	15.4	25	S. 70° W.	16.2	25	S. 74° W.	17.5	23	S. 81° W.	19.3
W	43	N. 81° W.	7.7	42	N. 87° W.	11.7	42	W.	15.3	42	N. 87° W.	16.8	39	N. 84° W.	17.4	36	N. 85° W.	20.0
WNW	111	N. 70° W.	10.1	106	N. 68° W.	13.1	107	N. 68° W.	15.5	105	N. 64° W.	15.7	103	N. 63° W.	16.0	94	N. 66° W.	16.6
NW	108	N. 57° W.	10.2	106	N. 47° W.	12.9	106	N. 45° W.	14.8	104	N. 46° W.	15.1	102	N. 46° W.	14.8	87	N. 50° W.	15.7
NNW	42	N. 50° W.	7.7	42	N. 30° W.	10.9	42	N. 22° W.	13.0	38	N. 26° W.	13.2	36	N. 29° W.	12.9	32	N. 31° W.	12.7
Yearly mean	562	N. 86° W.	-3.5	550	W.	5.4	550	W.	7.2	530	N. 87° W.	8.6	501	N. 84° W.	9.8	429	N. 84° W.	12.3

TABLE XXVII.—*Resultant air movement at each level*—Concluded.

YEAR—Continued.

Wind direction at 1,000 m.	2,500 m.			3,000 m.			3,500 m.			4,000 m.			4,500 m.			5,000 m.		
	Observations.	Wind.		Observations.	Wind.		Observations.	Wind.		Observations.	Wind.		Observations.	Wind.		Observations.	Wind.	
		Direction.	Velocity.		Direction.	Velocity.		Direction.	Velocity.		Direction.	Velocity.		Direction.	Velocity.		Direction.	Velocity.
			m.p.s.			*m.p.s.*			*m.p.s.*			*m.p.s.*			*m.p.s.*			*m.p.s.*
N.	5	N. 1° W.	11.4	3	N.	14.6	1	N. 22° E.	14.7	1	N. 22° E.	15.9						
NNE.	5	N. 6° E.	11.9	4	N. 3° E.	13.7	2	N. 29° W.	16.2									
NE.	2	N. 6° W.	11.9	2	N. 28° W.	14.8	2	N. 29° W.	16.0	1	N. 68° W.	23.8						
ENE.																		
E.																		
ESE.	2	S. 24° E.	15.7	1	S. 45° W.	19.8												
SE.	1	S. 45° W.	15.8															
SSE.	15	S. 46° W.	13.4	13	S. 50° W.	14.6	4	S. 89° W.	17.9	2	N. 88° W.	21.2	1	S. 68° W.	21.5	1	S. 68° W.	18.0
S.	42	S. 38° W.	16.8	28	S. 45° W.	18.1	17	S. 55° W.	20.4	9	S. 68° W.	22.8						
SSW.	36	S. 57° W.	16.3	29	S. 62° W.	18.9	22	S. 56° W.	21.6	14	S. 68° W.	20.8	9	S. 76° W.	20.5	5	S. 74° W.	20.3
SW.	23	S. 76° W.	19.7	20	S. 82° W.	22.3	15	S. 78° W.	21.5	7	S. 89° W.	21.0	3	N. 76° W.	21.7			
WSW.	17	S. 81° W.	18.3	14	S. 79° W.	20.1	9	S. 78° W.	18.4	5	S. 78° W.	21.1	2	W.	26.2	2	W.	27.6
W.	33	N. 88° W.	20.5	23	N. 88° W.	21.5	15	N. 88° W.	20.3	10	S. 83° W.	22.0	7	S. 80° W.	24.9	4	W.	26.4
WNW.	78	N. 68° W.	17.1	62	N. 72° W.	18.1	42	N. 73° W.	19.0	27	N. 78° W.	22.4	19	N. 78° W.	24.4	6	N. 86° W.	25.4
NW.	74	N. 54° W.	17.1	51	N. 61° W.	18.2	31	N. 59° W.	18.9	20	N. 67° W.	20.6	12	N. 59° W.	20.3	3	N. 56° W.	23.6
NNW.	26	N. 34° W.	13.7	20	N. 38° W.	16.6	13	N. 35° W.	19.2	9	N. 34° W.	19.7	6	N. 26° W.	20.8	5	N. 31° W.	24.4
Yearly mean.	359	N. 85° W.	13.9	270	N. 85° W.	15.9	173	N. 85° W.	17.2	105	N. 84° W.	19.7	50	N. 78° W.	20.9	26	N. 78° W.	21.6

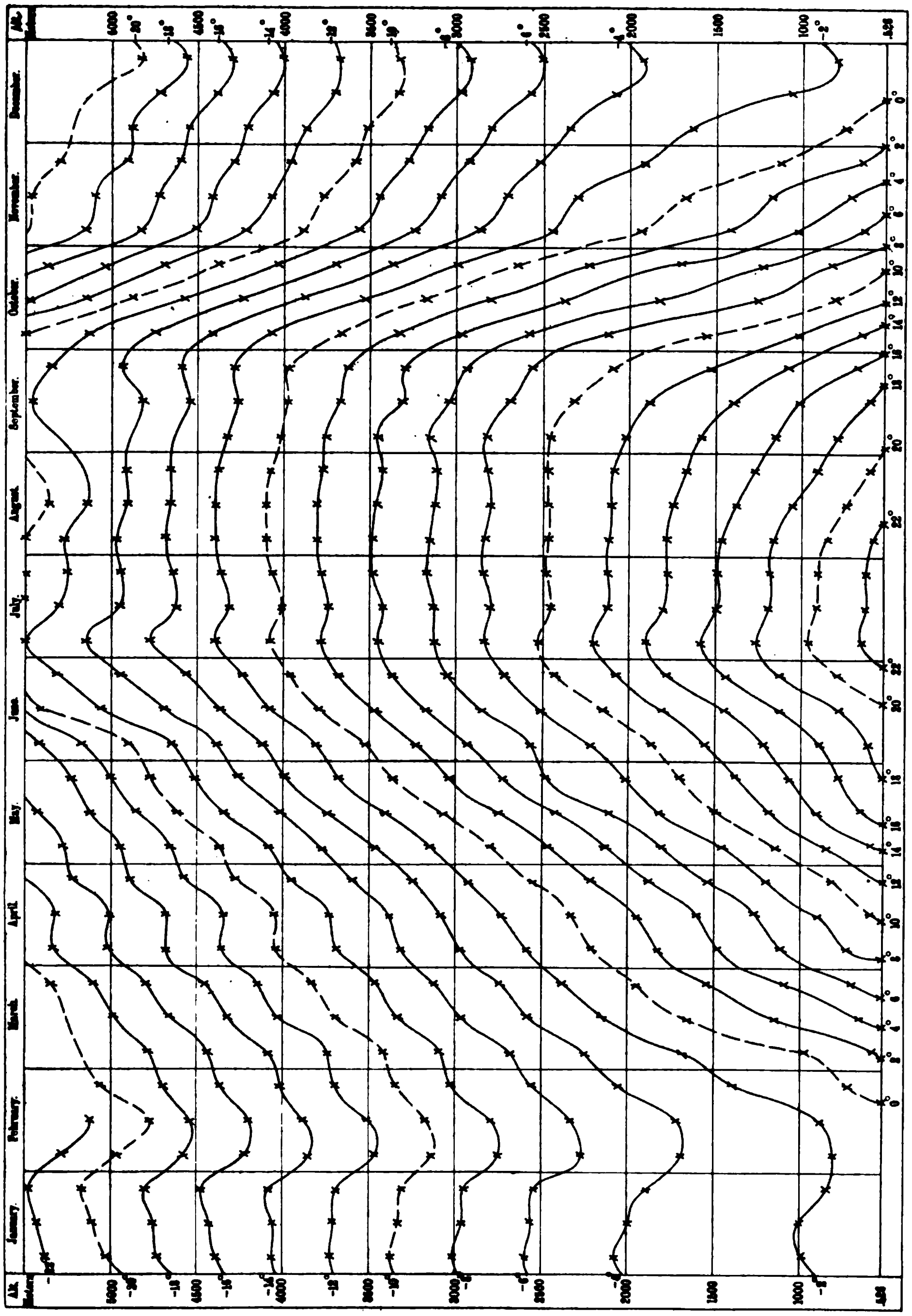
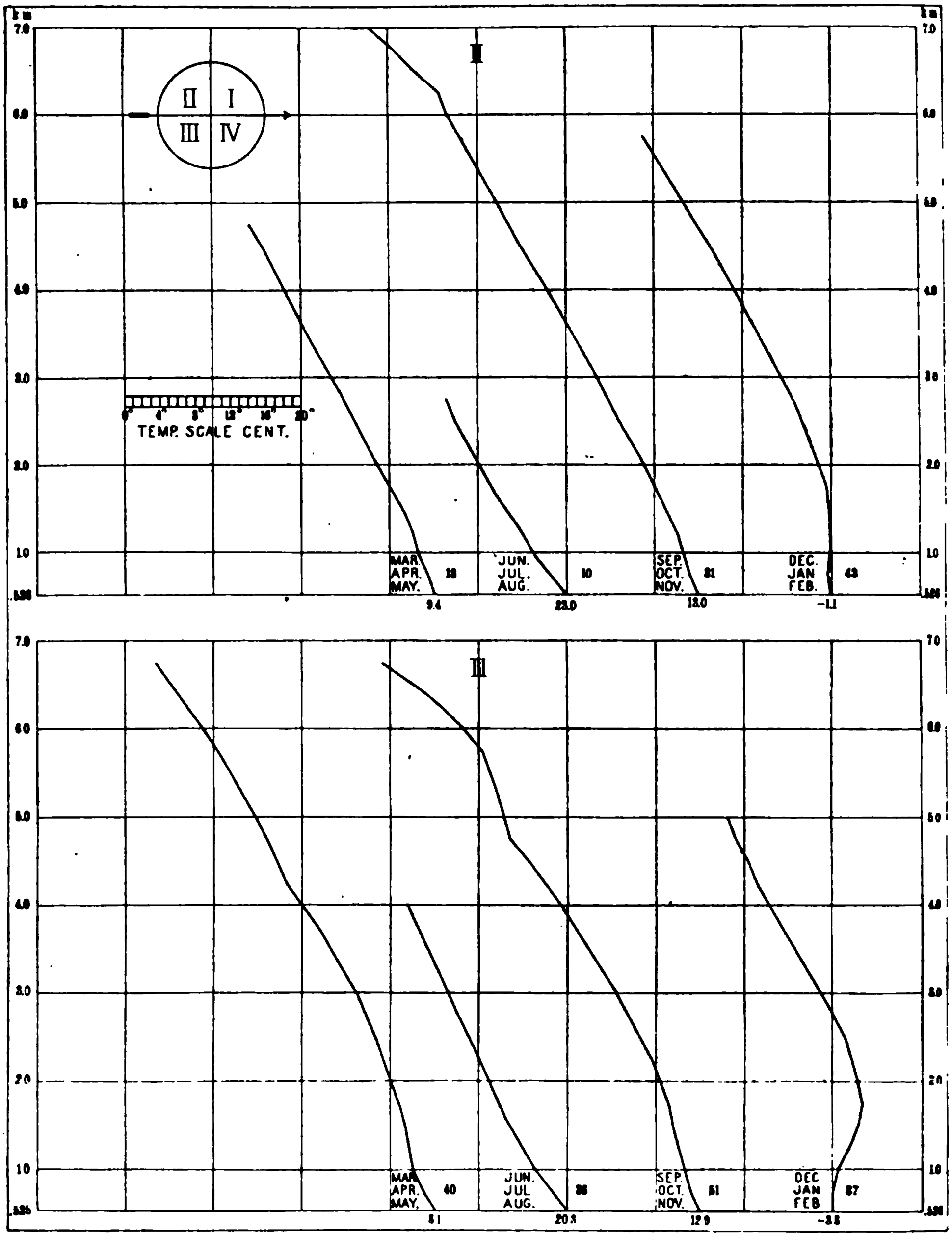
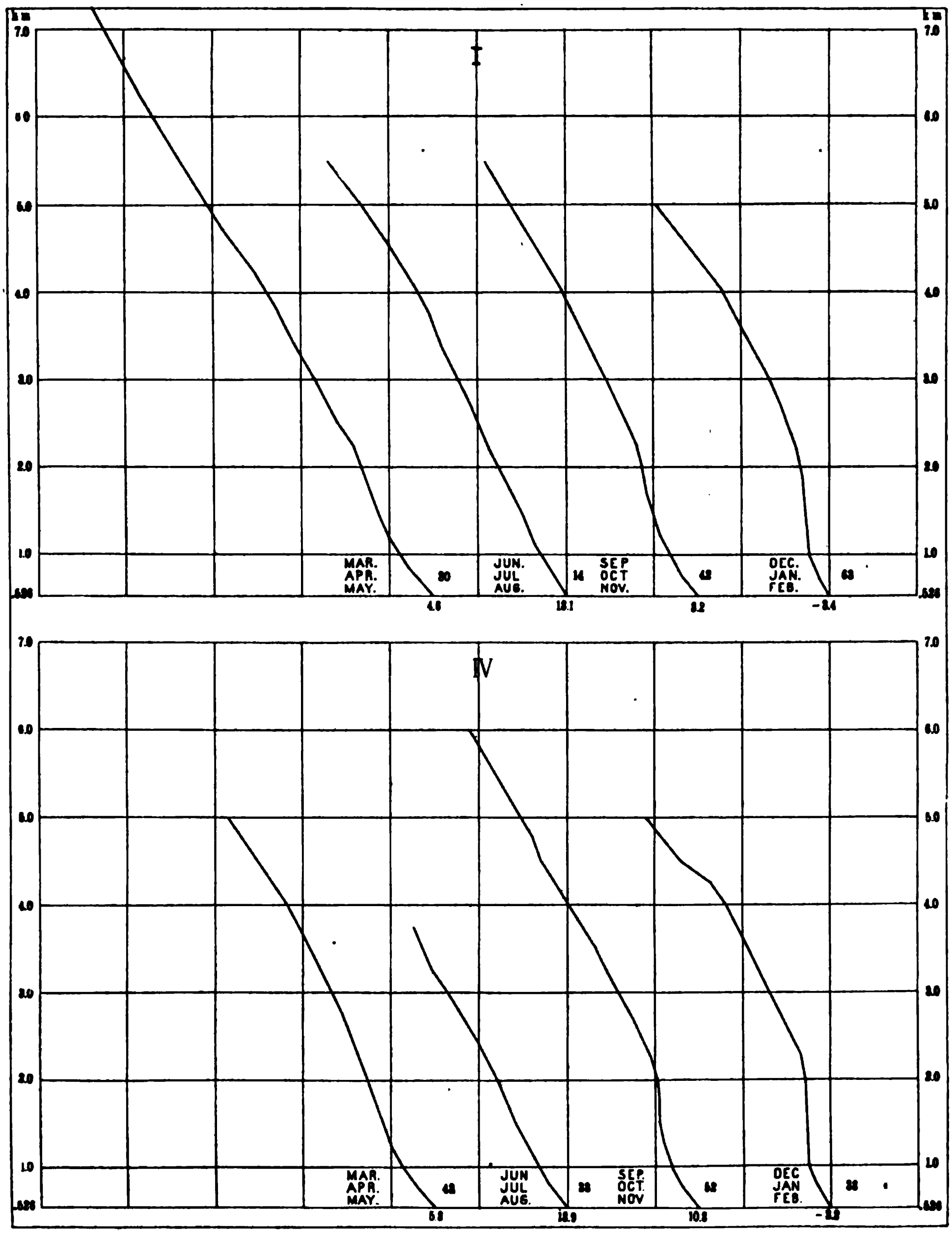


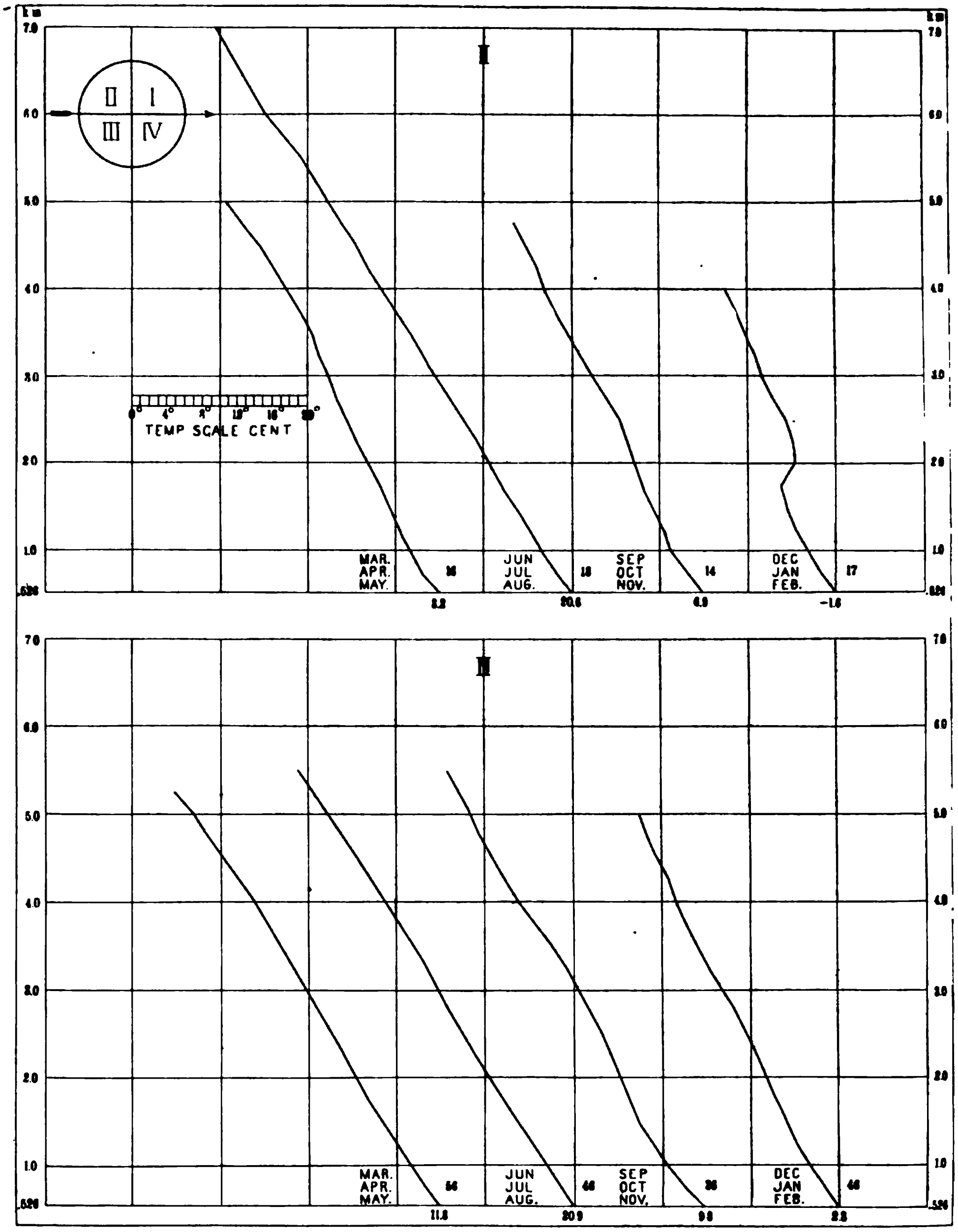
FIG. 1. Mean free air temperatures, July 1, 1907 to June 30, 1912.


km
I
II
III
IV
TEMP. SCALE CENT.
MAR. APR. MAY.
JUN. JUL. AUG.
SEP. OCT. NOV.
DEC. JAN. FEB.
III

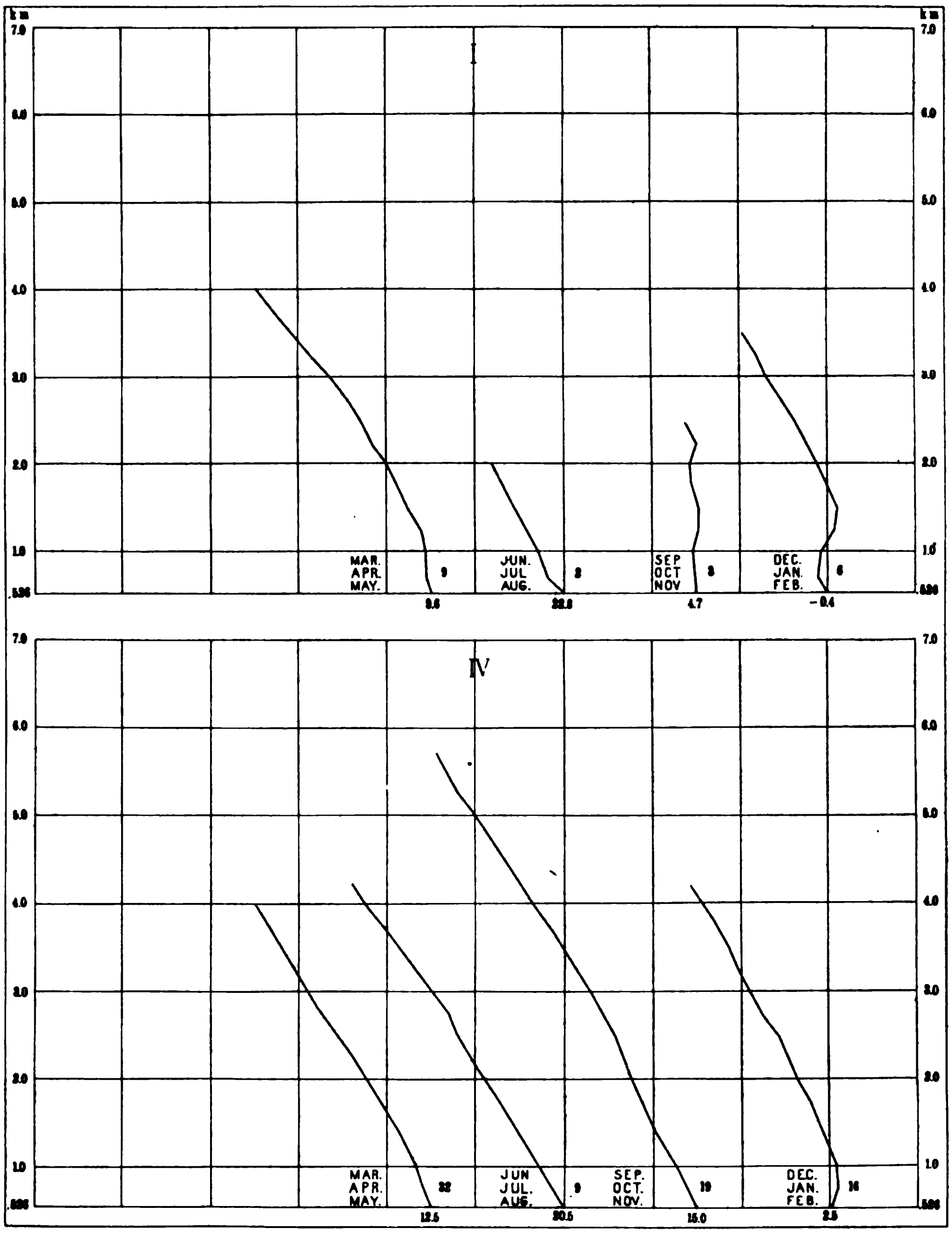
FIGS. 3 and 4.


I
7.0
6.0
5.0
4.0
3.0
2.0
1.0
MAR. APR. MAY.
JUN. JUL AUG.
14
18.1
SEP OCT NOV.
DEC. JAN. FEB.
IV
MAR. APR. MAY.
JUN JUL AUG.
SEP. OCT. NOV
10.8
DEC JAN FEB.

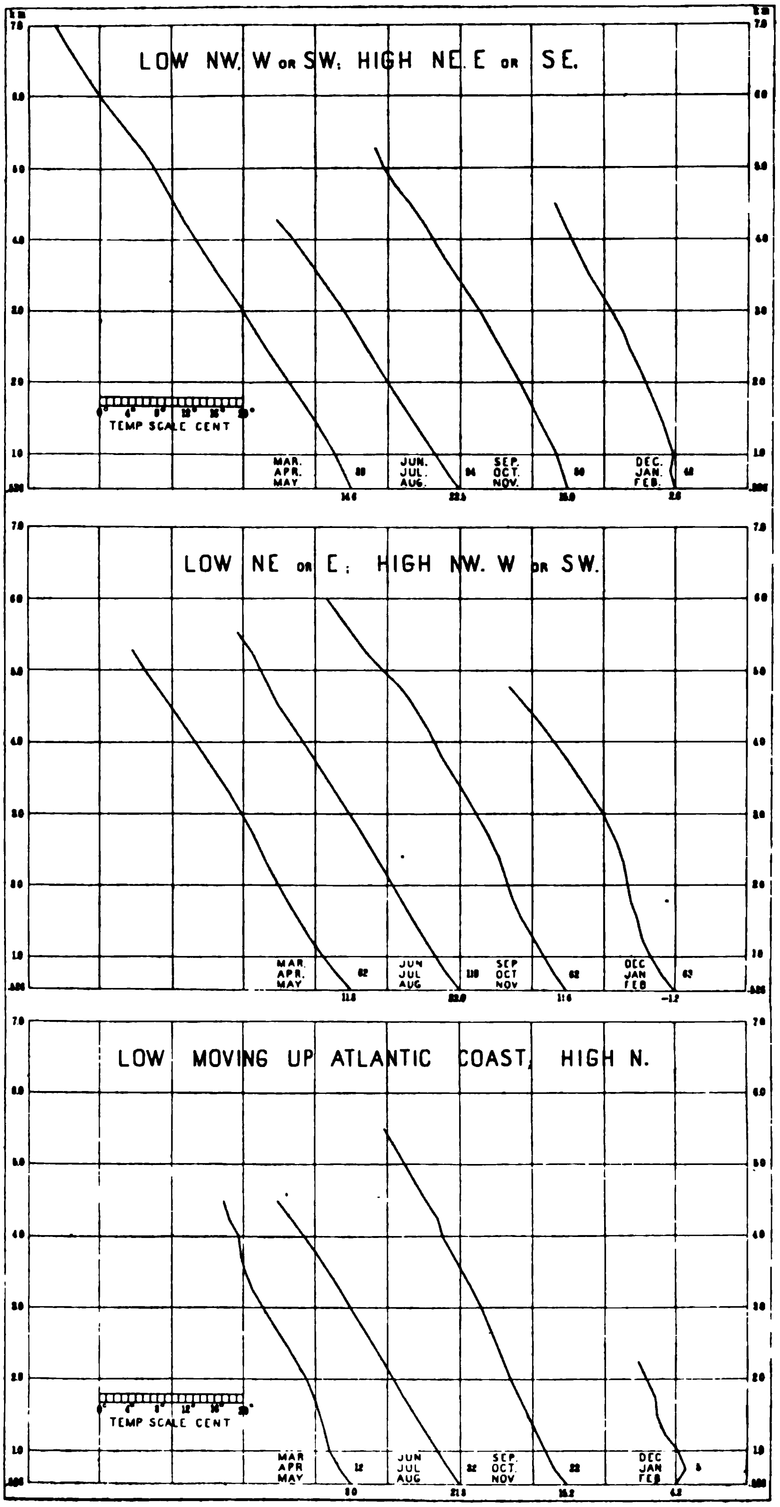
FIGS. 2 and 5.


TEMP SCALE CENT
MAR. APR. MAY.
JUN JUL AUG.
SEP OCT NOV.
DEC JAN FEB.
MAR. APR. MAY.
JUN JUL AUG.
SEP OCT NOV.
DEC JAN FEB.

FIGS. 7 and 8.


km
7.0
6.0
5.0
4.0
3.0
2.0
1.0
I
MAR.
APR.
MAY.
9
JUN.
JUL
AUG.
SEP
OCT
NOV
4.7
DEC.
JAN.
FEB.
6
– 0.4
IV
MAR.
APR.
MAY.
12.5
JUN
JUL.
AUG.
9
SEP.
OCT.
NOV.
15.0
DEC.
JAN.
FEB.
2.5

Figs. 6 and 9.



Figs. 10, 11, and 12.

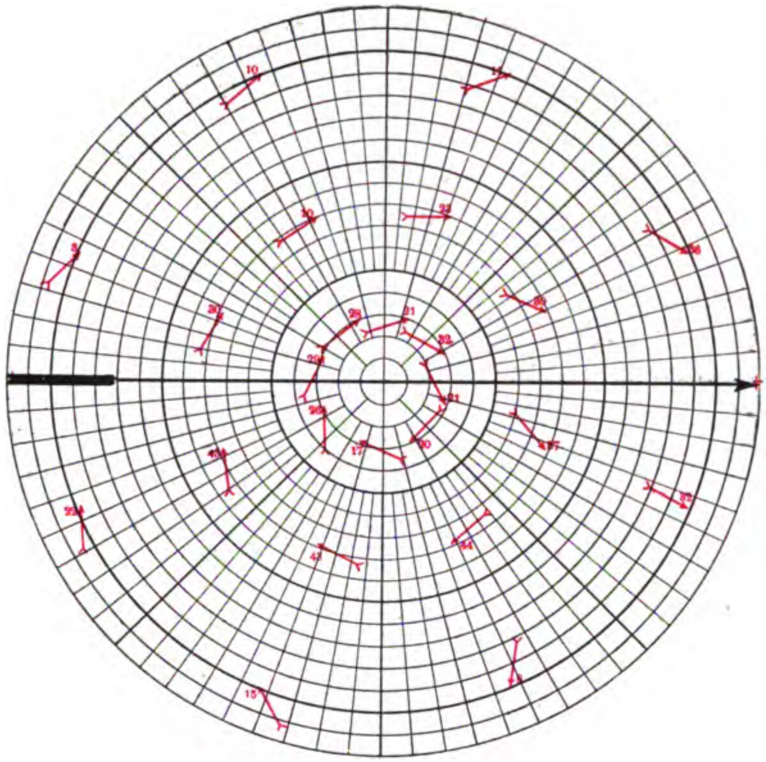


FIG. 14. Means of wind observations in "Highs" at 1,000 meters above sea level, 1907-1912.

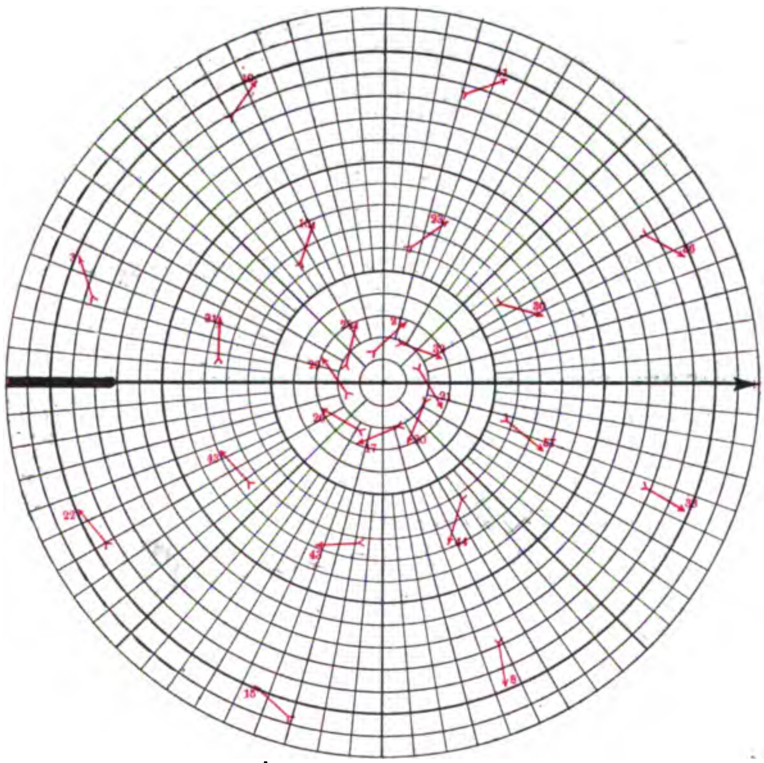


FIG. 13. Means of wind observations in "Highs" at 526 meters above sea level, 1907-1912.

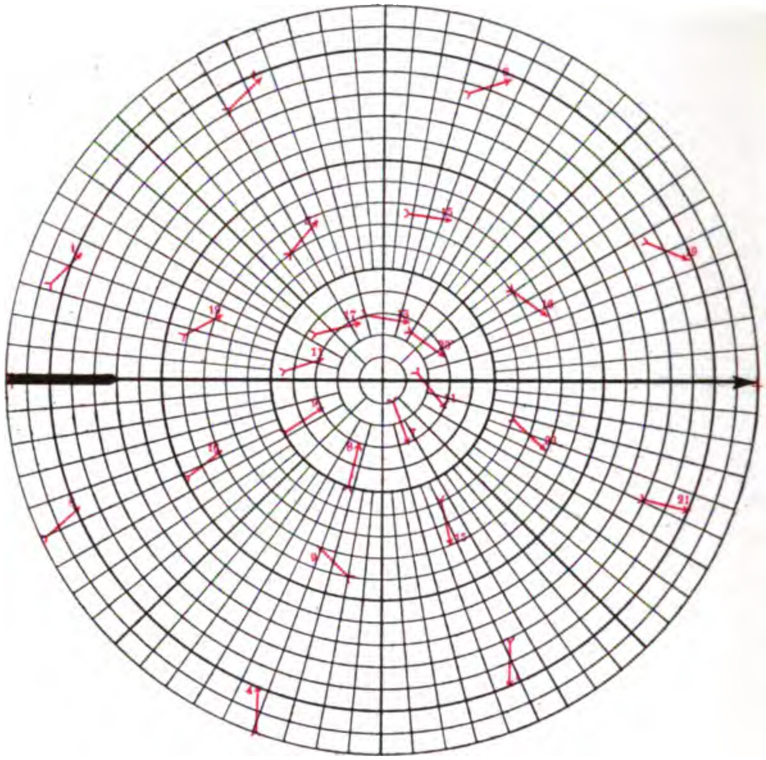


FIG. 16. Means of wind observations in "Highs" at 3,000 meters above sea level, 1907–1912.

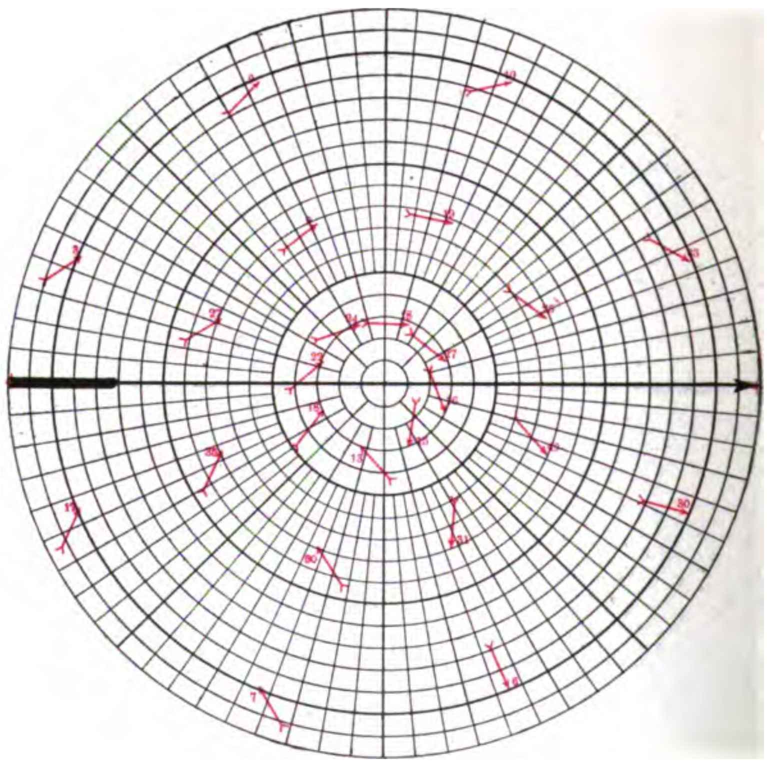


FIG. 15. Means of wind observations in "Highs" at 2,000 meters above sea level, 1907–1912.

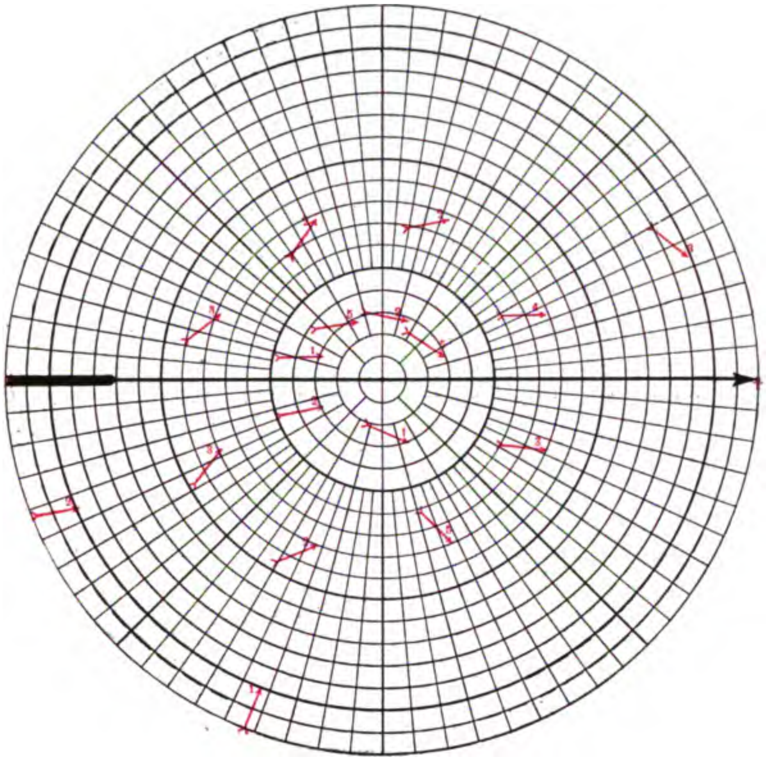


FIG. 18. Means of wind observations in "Highs" at 5,000 meters above sea level, 1907-1912.

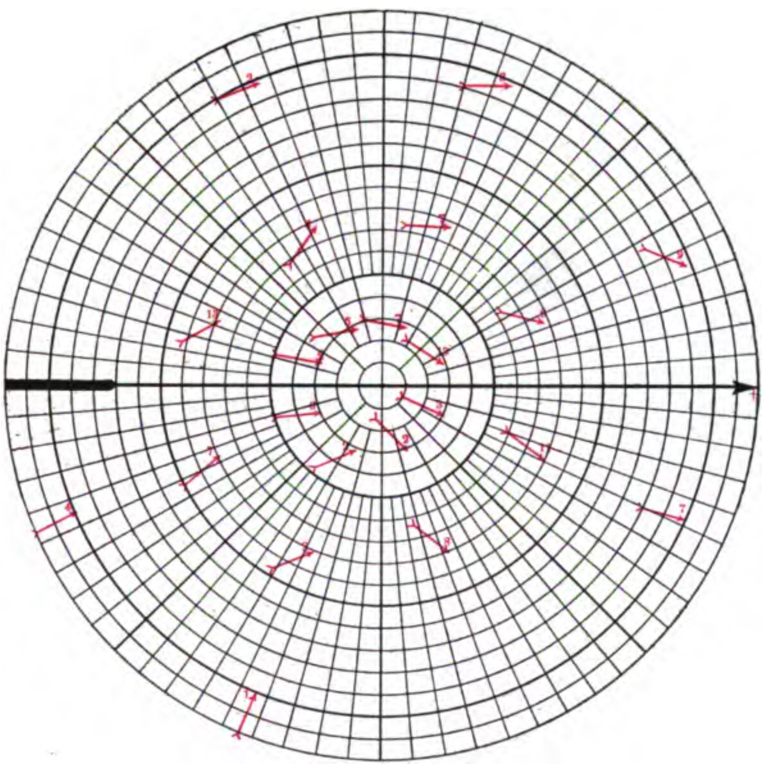


FIG. 17. Means of wind observations in "Highs" at 4,000 meters above sea level, 1907-1912.

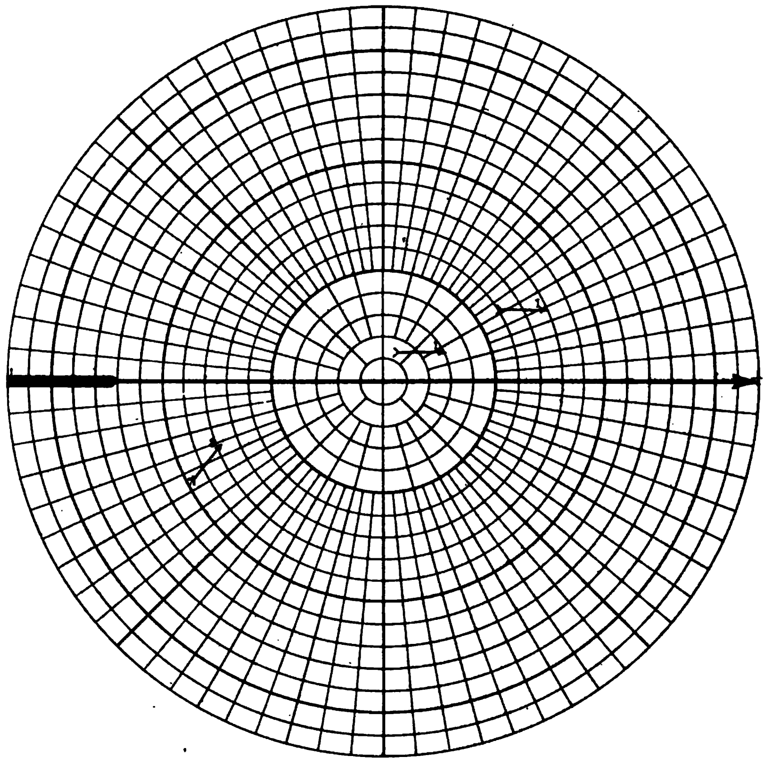


FIG. 20. Means of wind observations in "Highs" at 7,000 meters above sea level, 1907-1912.

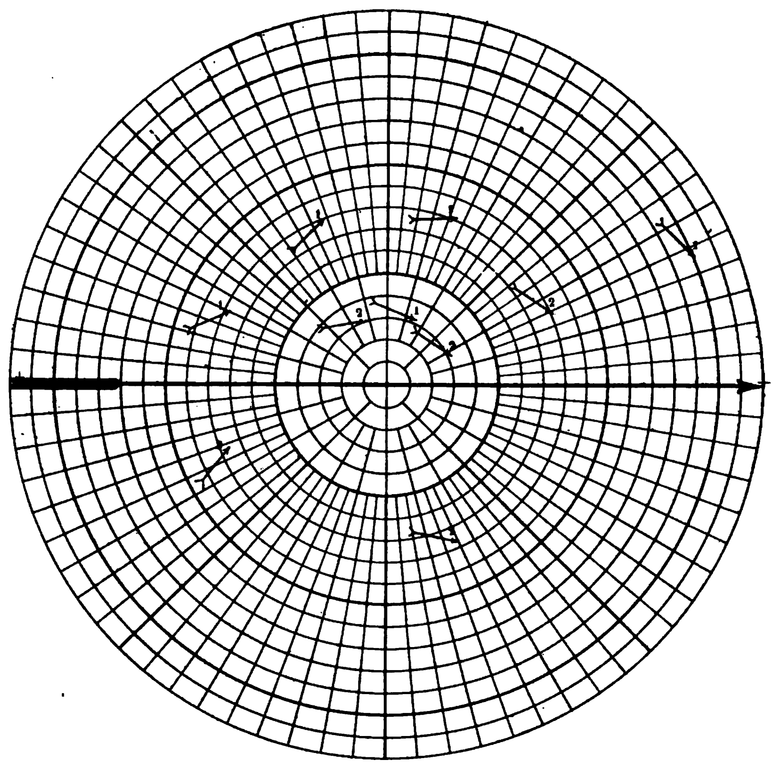


FIG. 19. Means of wind observations in "Highs" at 6,000 meters above sea level, 1907-1912.

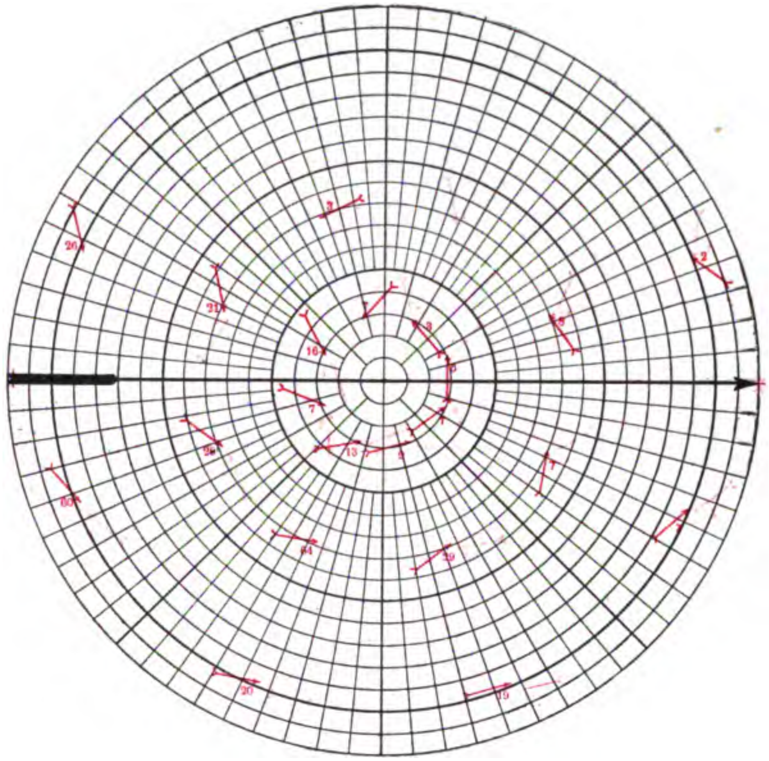


FIG. 22. Means of wind observations in "Lows" at 1,000 meters above sea level, 1907-1912.

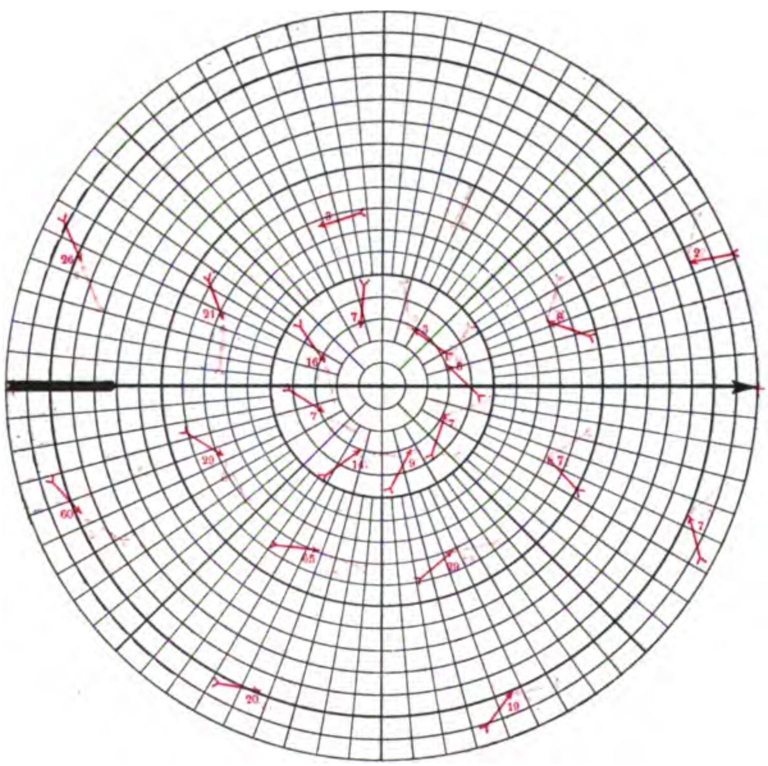


FIG. 21. Means of wind observations in "Lows" at 526 meters above sea level, 1907-1912.

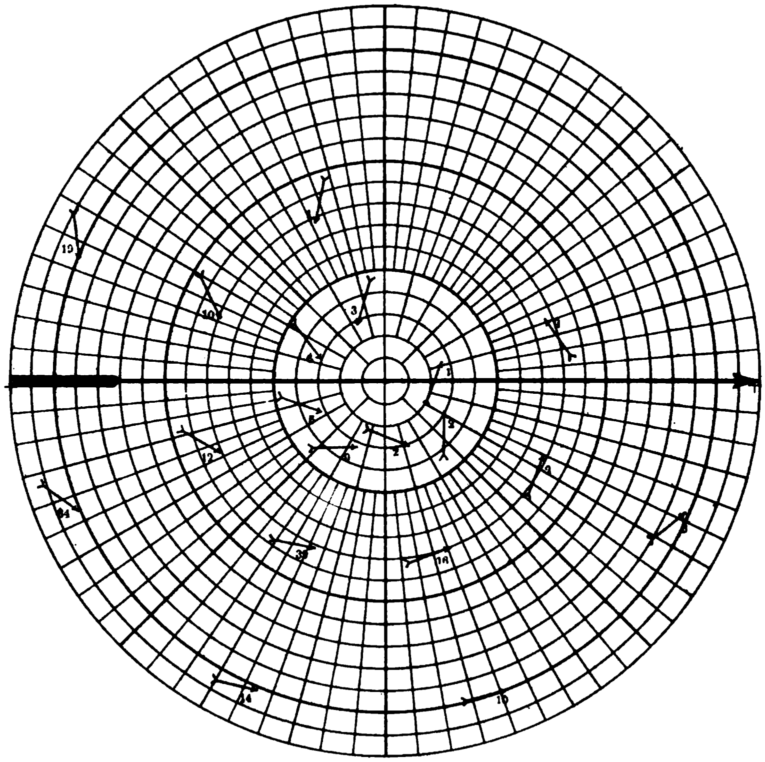


FIG. 24. Means of wind observations in "Lows" at 3,000 meters above sea level, 1907-1912.

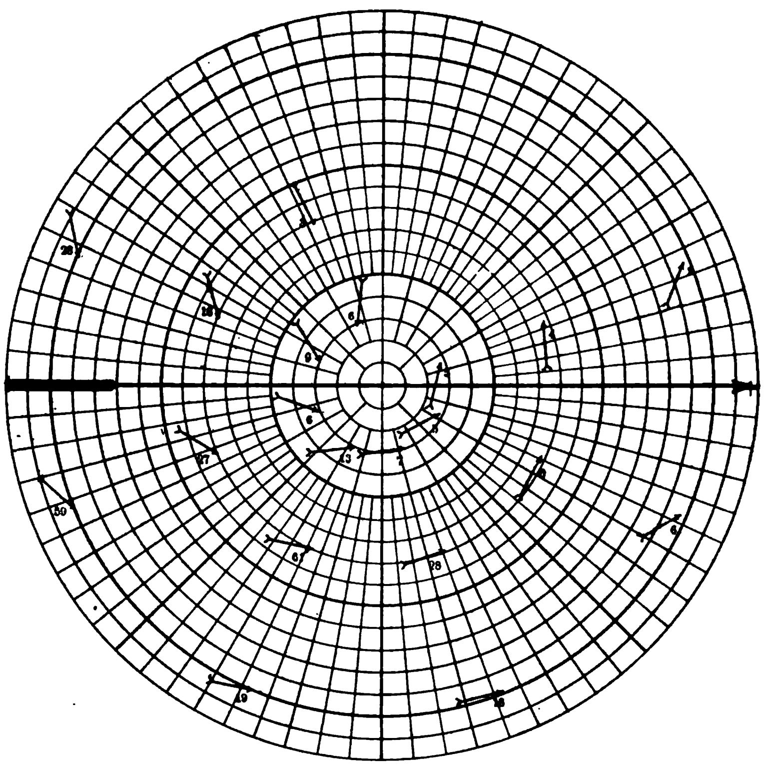


FIG. 23. Means of wind observations in "Low" at 2,000 meters above sea level, 1907-1912.

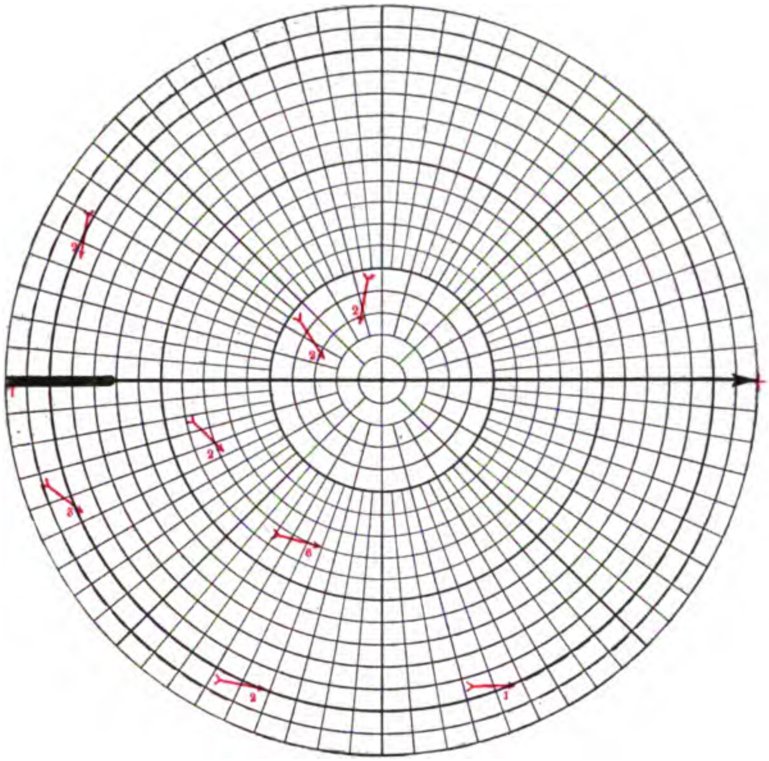


FIG. 26. Means of wind observations in "Lows" at 5,000 meters above sea level, 1907-1912.

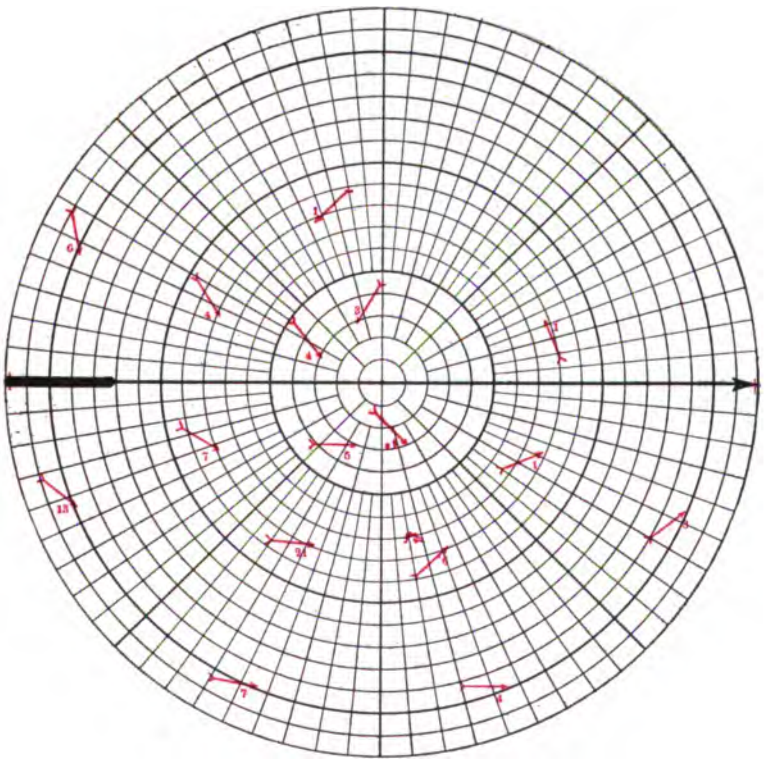


FIG. 25. Means of wind observations in "Lows" at 4,000 meters above sea level, 1907-1912.

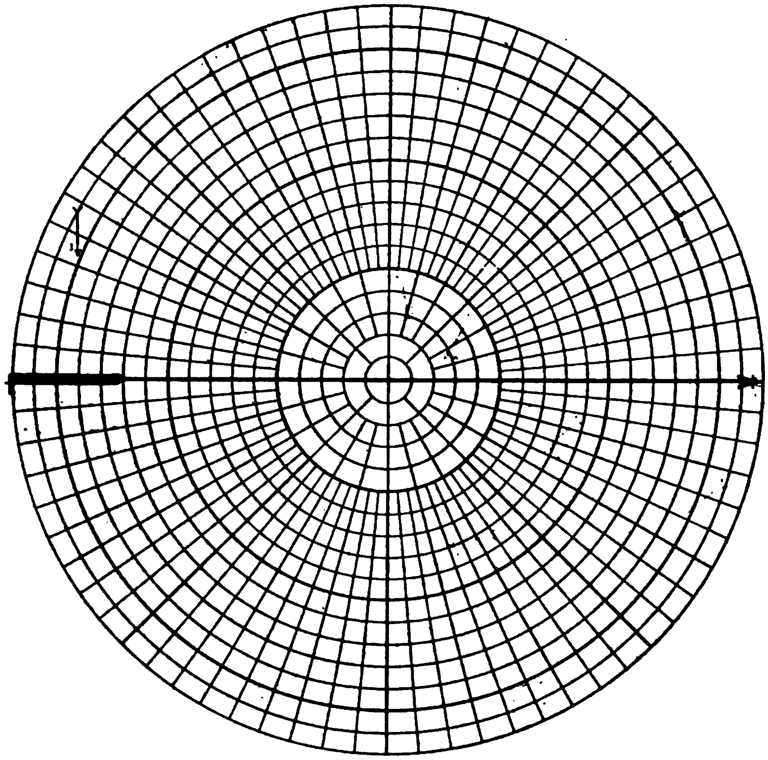


FIG. 28. Means of wind observations in "Low" at 7,000 meters above sea level, 1907-1912.

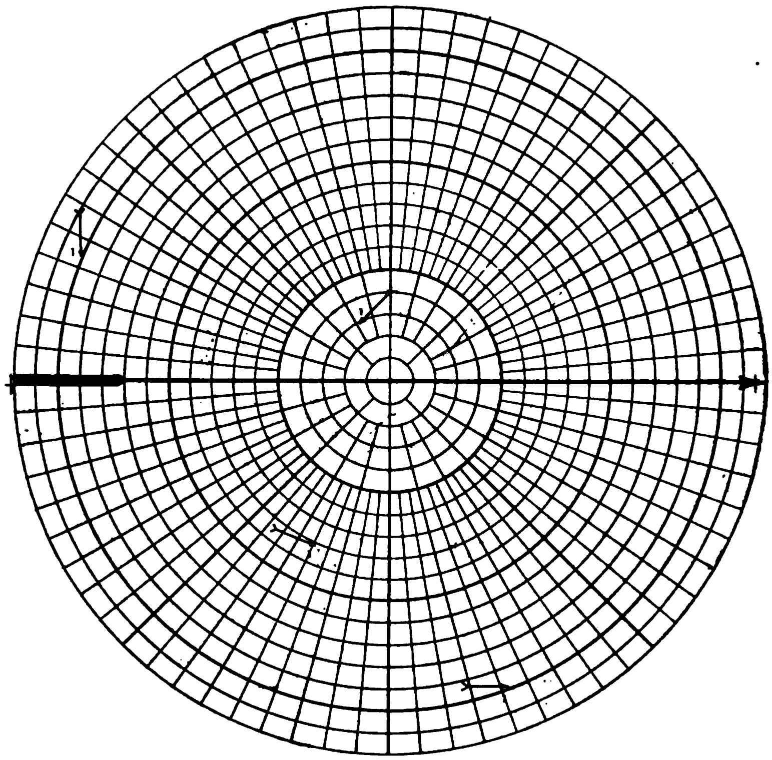


FIG. 27. Means of wind observations in "Lows" at 6,000 meters above sea level, 1907-1912.

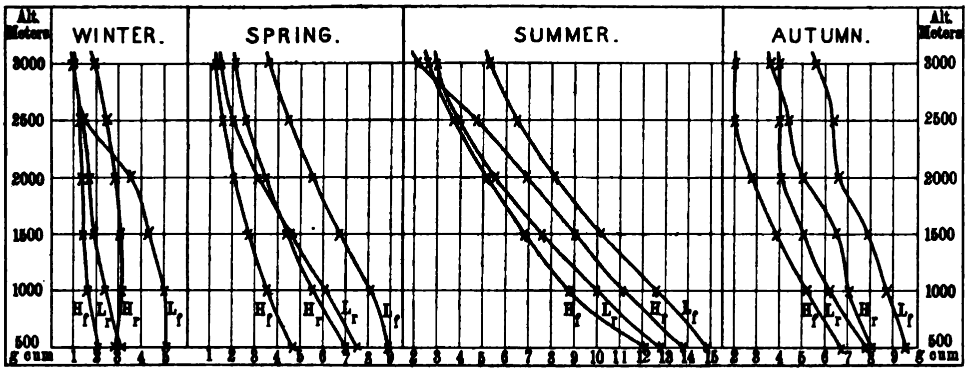


FIG. 29. Variation in absolute humidity with altitude up to 3 kilometers, for different types of surface air pressure and for the seasons.

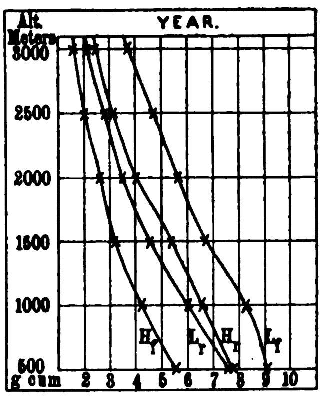


FIG. 30. Variation in absolute humidity with altitude up to 3 kilometers, for different types of surface air pressure and for the year.

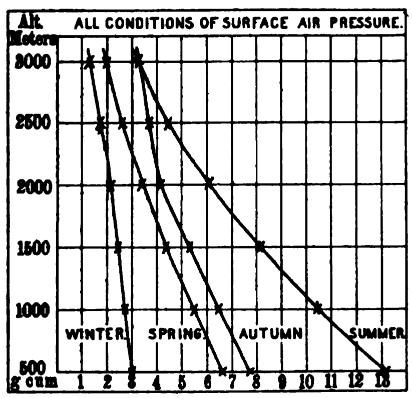


FIG. 31. Variation in absolute humidity with altitude up to 3 kilometers, for the seasons.

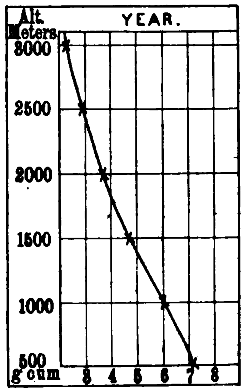


FIG. 32. Variation in absolute humidity with altitude up to 3 kilometers, for the year.

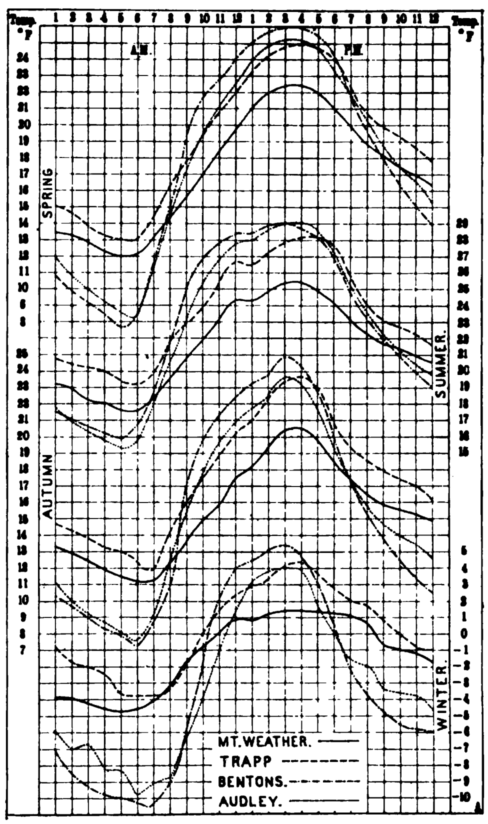


FIG. 33. The diurnal variation of temperature on clear comparatively quiet days at the mountain and valley stations.

W. B. No. 532 Issued August 20, 1914

U. S. DEPARTMENT OF AGRICULTURE

WEATHER BUREAU

CHARLES F. MARVIN, Chief

Vol. 6 Part 5 Final Number

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OF THE

MOUNT WEATHER OBSERVATORY

WASHINGTON
GOVERNMENT PRINTING OFFICE
1914

The Weather Bureau

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Vol. VI, Part 5. FINAL NUMBER. Closed May 20, 1914.
W. B. No. 532. CLEVELAND ABBE, Editor. Issued Aug. 20, 1914.

10. THE DESIGN AND THEORY OF A MECHANISM FOR ILLUSTRATING CERTAIN SYSTEMS OF LINES OF FORCE AND STREAM LINES.[1]

WILLIAM H. ROEVER, *Professor of Astronomy.*

[Dated Washington University, St. Louis, Mo., November, 1912.]

1. *Description of mechanism.*—The mechanism, which is shown in photographs 1 and 2, consists essentially of two wheels, about eight inches in diameter, which are capable of rotating around parallel axes in planes, which are not more than one-half inch apart. These wheels are provided either with spokes, as shown in photograph figure 1, or with slotted webs, as shown in photograph figure 2. The rest of the mechanism consists of a hand motor and a series of belt-driven cone pulleys, by means of which the wheels just described may be given various angular velocity ratios.

When the motor is put into operation, the observer will see a system of curves, the nature of which depends on the velocity ratio and the forms of the spokes or slots of the wheels.

These curves are the loci of the points of intersection of the spokes or slots of one wheel with those of the other. It is the object of this paper to show that when the spokes or slots are radiating straight lines (as shown in photograph fig. 1) or co-polar congruent logarithmic spirals of any form (as, for instance, those shown in photograph, fig. 2), the observed system of curves represents the lines of force or the stream lines, which correspond to a problem in each of several branches of mathematical physics. The accompanying photographs figures 3 to 10 show a few of the systems which the machine can produce.

[1] Presented to the American Mathematical Society, April and November, 1912. *See* Bull. Amer. Math. Soc. 18, no. 9, p. 435, and 19, no. 5, p. 220. Published simultaneously in Zeitschrift für Mathematik und Physik, (gegr. von Schlömilch), Leipzig, 1914, 62.

2. *Two special fields of force.* In order to have a starting point let us consider the following two fields of force.

Field I. The electrostatic force at a point P (fig. 11), at distance r from an infinite straight line which carries a uniform charge λ per unit length, is represented in magnitude by the expression $\frac{2\lambda}{r}$ (C. G. S. units). The vector representing this force has its origin at P and lies along the perpendicular from P to the electrified line. Since the particle at P is supposed to be positive, the vector is directed away from or toward the line according as λ is positive or negative.

Field II. The electromagnetic force at a point P (fig. 12), at the distance r from an infinite straight wire which carries a constant current of electricity j, is represented in intensity by the expression $\frac{2j}{r}$ (C. G. S. units). The vector representing this force has its origin at P and lies along that straight line which passes through P and is perpendicular both to the wire and the perpendicular from P to the wire. The direction of this vector is such that the arrowhead is toward the left hand of a person facing P and swimming in the current which flows from his feet to his head.

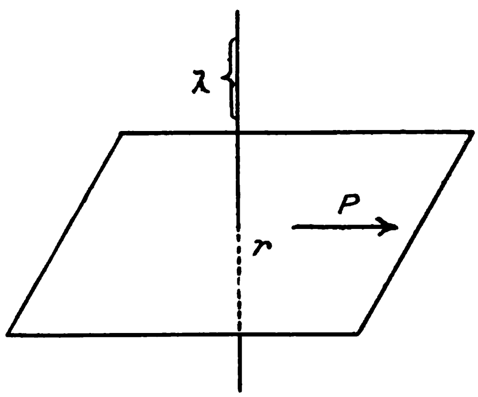


FIG. 11.—Field I.

3. *Fields I and II in terms of a complex variable.*—The fields I and II, just described, can be very simply represented in terms of the complex variable.

Field I in terms of the complex variable.—Let the plane π which passes through P and is perpendicular to the electrified line, be that of the complex variable, the zero of which is at the point in which the electrified line pierces π. The point P is then a general point $z=x+iy$ of this plane. If we now think of the point $z=0$ as the abode of a particle of mass $m=2\lambda$, the law of the intensity of the force being that of the inverse distance, then the vector represented in Fig. 11 and described in section 2, is completely represented by the complex quantity

$$(1) \qquad m \cdot K\left(\frac{1}{z}\right)$$

in whi h the symbol $K\left(\frac{1}{z}\right)$ star ds for the cor jugate of $\frac{1}{z}$ (see Fig. 13).

Field II in terms of the complex variable.—Now let the plane π, which passes through P (fig. 12) and is perpendicular to the wire carrying the electric current, be regarded as that of the complex variable, the zero of which is at the point in which the wire pierces π. If now we put $n=2j$, it is easy to see that the vector represented in figure 12 and described in section 2 is completely represented by the complex quantity

$$niK\left(\frac{1}{z}\right). \tag{2}$$

4. *Imaginary and Complex Masses.*—It appears from this method of representation that we may regard the force of field I as due to a real mass m, and that of field II as due to a pure imaginary mass ni.

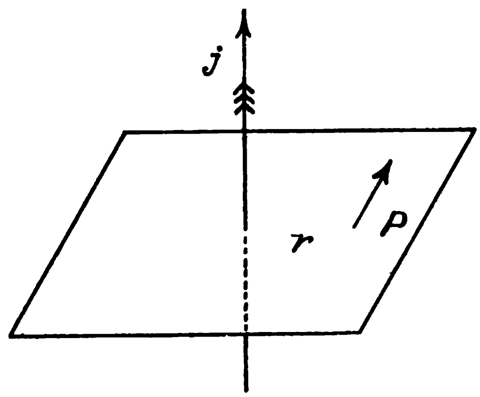


FIG. 12.—Field II.

Field III.—Disregarding for the moment the possibility of physical interpretation, let us now imagine that the point $z=0$ is the abode of a complex mass

$$\mu=m+ni$$

where m and n are real numbers, and that the force at a general point z (fig. 13) is the resultant of the two forces just formulated in section 3, namely

$$\mu K\left(\frac{1}{z}\right). \tag{3}$$

Field IV.—Furthermore, let us assume that the force at a general point z of the complex plane which is due to the two complex masses

$$\mu_1 = m_1 + n_1 i, \qquad \mu_2 = m_2 + n_2 i,$$

situated respectively at the points z_1 and z_2, is represented by the complex expression

$$f=\mu_1 K\left(\frac{1}{z-z_1}\right)+\mu_2 K\left(\frac{1}{z-z_2}\right). \tag{4}$$

5. *Equations of lines of force of Field III.*—Let us now obtain the lines of force of the field III due to the complex mass $\mu=m+ni$ at the origin. In order to do this let us put

$$z=r(\cos\varphi+i\sin\varphi)$$

where

$$r=\sqrt{x^2+y^2}, \qquad \sin\varphi=\frac{y}{r}, \qquad \cos\varphi=\frac{x}{r}.$$

Then

$$\frac{1}{z}=\frac{1}{r}(\cos\varphi-i\sin\varphi),$$

$$K\left(\frac{1}{z}\right)=\frac{1}{r}(\cos\varphi+i\sin\varphi),$$

and since

$$\mu=m+ni,$$

$$\mu K\left(\frac{1}{z}\right)=X+Yi,$$

where

$$X=\frac{1}{r}(m\cos\varphi-n\sin\varphi),\quad Y=\frac{1}{r}(m\sin\varphi+n\cos\varphi).$$

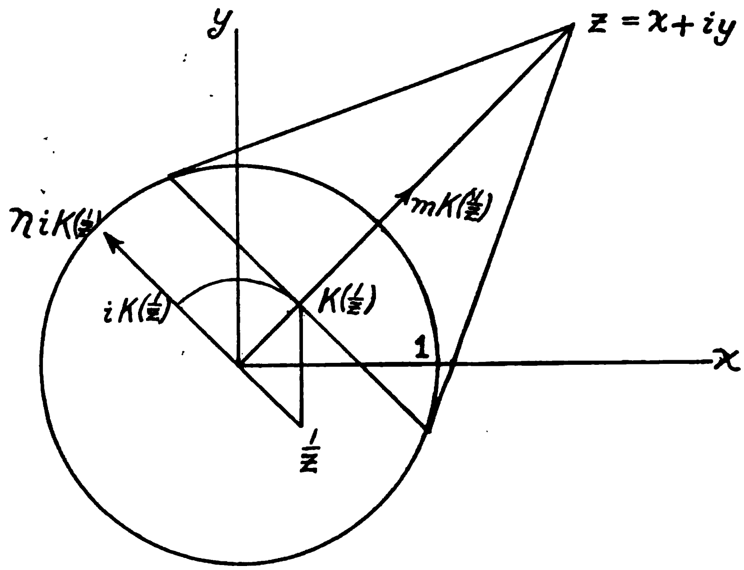


FIG. 13.—Field III.

Now

$$X=\frac{\partial U}{\partial x}\quad\text{and}\quad Y=\frac{\partial U}{\partial y},$$

where

$$U=m\log r+n\varphi.$$

Hence the function U may be regarded as the potential function of field III.

But U is the real part of the analytic function

$$(m-ni)\log z=U+Vi.$$

Therefore the pure imaginary part,

$$V=-n\log r+m\varphi,$$

may be regarded as the stream function.

Hence the equation

$$(3_0) \qquad V = \text{constant}$$

is that of the lines of force of field III.

The curves (3_0) are the copolar logarithmic spirals which cut the straight lines through the origin at the constant angle $\alpha = \text{arc cot}\frac{m}{n}$.

When $\mu = m$ is real, equation (3_0) takes the form

$$(3_1) \qquad \varphi = \text{constant},$$

and when $\mu = ni$ is a pure imaginary, then equation (3_0) becomes

$$(3_2) \qquad \log r = \text{constant}.$$

These are the lines of force of fields I and II respectively.

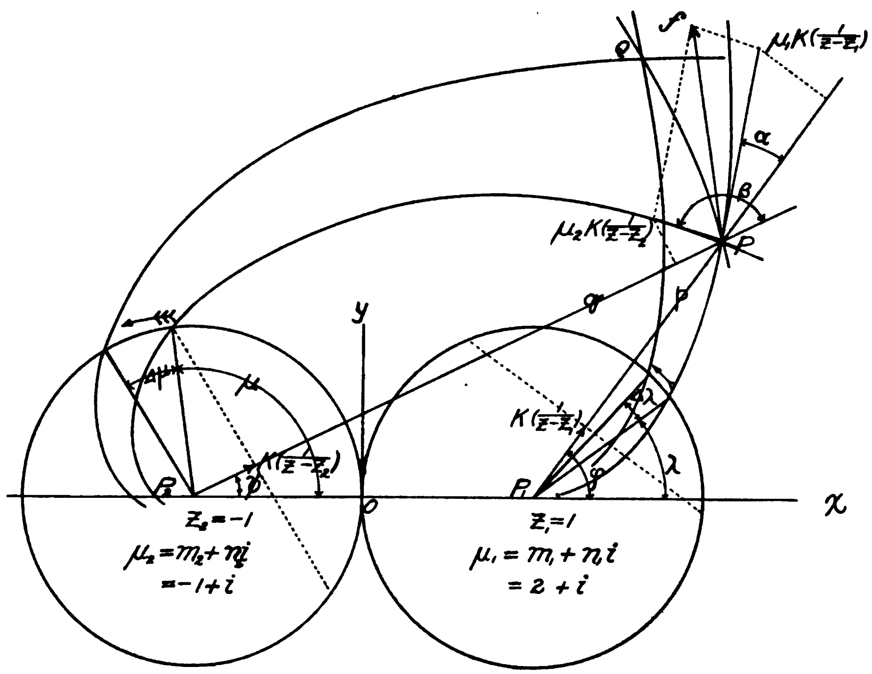


Fig. 14.—Field IV.

6. *Equations of lines of force of Field IV.*—Let us now obtain the lines of force of field IV due to the complex masses $\mu_1 = m_1 + n_1 i$ and $\mu_2 = m_2 + n_2 i$ which are situated at the points z_1 and z_2 respectively. For the problem in hand no generality will be lost in assuming (see Fig. 14) $z_1 = 1$ and $z_2 = -1$. Then let us put

$$z - z_1 = z - 1 = p\ (\cos\varphi + i\sin\varphi),$$

$$z - z_2 = z + 1 = q\ (\cos\psi + i\sin\psi),$$

where

$$p=\sqrt{(x-1)^2+y^2}, \qquad q=\sqrt{(x+1)^2+y^2},$$

$$\sin\varphi=\frac{y}{p}, \quad \cos\varphi=\frac{x-1}{p}, \qquad \sin\psi=\frac{y}{q}, \quad \cos\psi=\frac{x+1}{q}.$$

Then

$$K\left(\frac{1}{z-z_1}\right)=\frac{1}{p}(\cos\varphi+i\sin\varphi),$$

$$K\left(\frac{1}{z-z_2}\right)=\frac{1}{q}(\cos\psi+i\sin\psi).$$

Since

$$\mu_1=m_1+n_1i,$$

and

$$\mu_2=m_2+n_2i,$$

therefore,

$$\mu_1K\left(\frac{1}{z-z_1}\right)=X_1+Y_1i,$$

and

$$\mu_2K\left(\frac{1}{z-z_2}\right)=X_2+Y_2i,$$

where

$$X_1=\frac{1}{p}(m_1\cos\varphi-n_1\sin\varphi),$$

$$X_2=\frac{1}{q}(m_2\cos\psi-n_2\sin\psi),$$

and

$$Y_1=\frac{1}{p}(m_1\sin\varphi+n_1\cos\varphi),$$

$$Y_2=\frac{1}{q}(m_2\sin\psi+n_2\cos\psi).$$

Now

$$X_1+X_2=\frac{\partial U}{\partial x}$$

and

$$Y_1+Y_2=\frac{\partial U}{\partial y},$$

where

$$U=m_1\log p+m_2\log q+n_1\varphi+n_2\psi.$$

This is the potential function of the field IV, and is the real part of the analytic function

$$(m_1-n_1 i)\log(z-z_1)+(m_2-n_2 i)\log(z-z_2)=U+Vi.$$

Therefore, the pure imaginary part

$$V=-n_1\log p-n_2\log q+m_1\varphi+m_2\psi$$

is the stream function.

Therefore the equation

$$(4_0)\qquad -n_1 \log p - n_2 \log q + m_1\varphi + m_2\psi = \text{constant},$$

is that of the lines of force of field IV.

When $\mu_1 = m_1$ and $\mu_2 = m_2$ are real, then equation (4_0) becomes

$$(4_1)\qquad m_1\varphi + m_2\psi = \text{constant},$$

and when $\mu_1 = n_1 i$ and $\mu_2 = n_2 i$ are pure imaginaries then equation (4_0) assumes the form

$$(4_2)\qquad n_1 \log p + n_2 \log q = \text{constant}.$$

7. *The theory of the mechanism.*—We are now in a position to prove that the systems of curves which are produced by the mechanism described in section 1 are represented by equations (4_0) of section 6.

The lines of force due to the mass $\mu_1 = m_1 + n_1 i = m_1(1 + i \tan \alpha)$ situated at the point $P_1, (z_1)$ are the logarithmic spirals

$$(5)\qquad -\tan \alpha \cdot \log p + \varphi = \lambda,$$

and those due to the mass $\mu_2 = m_2 + n_2 i = m_2(1 + i \tan \beta)$ situated at $P_2, (z_2)$ are

$$(6)\qquad -\tan \beta \cdot \log q + \psi = \nu.$$

Let us now put

$$(7)\qquad \lambda = at + b \quad \text{and} \quad \nu = ct + d,$$

where a, b, c, d are real constants and *t is a parameter which we will take to represent the time.*

By this assumption the spirals (5) and (6) (which are represented by the curves P_1P and P_2P respectively in figure 14) are made to rotate around their poles with constant angular velocities.

In order to eliminate t between equations (5) and (6), in which λ and ν have the values given by equations (7), it is only necessary to multiply (5) by c, (6) by $-a$ and add. The eliminant thus obtained is

$$(8)\qquad -c \tan \alpha \cdot \log p + a \tan \beta \cdot \log q + c\varphi - a\psi = bc - ad.$$

A comparison of this equation with the equation

$$-m_1 \tan \alpha \cdot \log p - m_2 \tan \beta \cdot \log q + m_1\varphi + m_2\psi = \text{constant},$$

which is identical with equation (4_0), enables us to state the following:

Theorem I.—The lines of force due to the two complex masses $\mu_1 = m_1(1 + i\tan\alpha)$ and $\mu_2 = m_2(1 + i\tan\beta)$, which are situated at the points P_1 and P_2 respectively, are the loci of the points of intersection of the logarithmic spirals which are the lines of force due to μ_1 alone with those which are the lines of force due to μ_2 alone, provided that these two rigid systems of spirals rotate around their respective poles with

angular velocities, the ratio of which is the negative reciprocal of the ratio of the real parts of μ_1 *and* μ_2, *that is, provided* $\frac{a}{c} = -\frac{m_2}{m_1}$.

If, for instance, $\mu_1 = 2 + i$ and $\mu_2 = -1 + i$ as shown in figure 14, then the spirals of pole P_2 must rotate twice as fast as those of P_1, and the rotations must be in the same sense.

We have before us also the proof of the following:

Theorem II.—If two systems of co-polar logarithmic spirals of angles α *and* β *rotate around their respective poles* P_1 *and* P_2 *with angular velocities which are proportional to a and c, then the loci of the points of intersection of the curves of one system with those of the other are the lines of force due to the two complex masses* $\mu_1 = m_1(1 + i\tan\alpha)$, $\mu_2 = m_2(1 + i\tan\beta)$, *which are situated at* P_1 *and* P_2 *respectively, the ratio of the real parts of which is the negative reciprocal of the ratio of the angular velocities, i. e.* $\frac{m_1}{m_2} = -\frac{c}{a}$.

Theorem I fails when both of the masses μ_1, μ_2 are *pure imaginaries*, and also when only one of these is a pure imaginary. For, the lines of force corresponding to a pure imaginary mass are concentric circles [see eq. (3_2)], and such circles on rotation around the common center would merely move along themselves. In these cases the mechanism also fails.

In all other cases, the theorem (and also the mechanism) does not fail. A special case of interest is that in which both masses are real. In this case the systems of spirals become systems of radiating right lines of radiants P_1 and P_2, and the corresponding loci are represented by the equations (4_1) (1).

8. *Applications.*—In section 4 we introduced the notion of complex masses without regard to the possibility of physical interpretation. Since then we have seen that the functions U and V of sections 5, 6 are the real and pure imaginary parts of analytic functions and hence satisfy Laplace's equation $\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} = 0$.

For this reason the systems of curves (4_0), which the mechanism described in section 1 is capable of representing (2), may be given the following physical interpretations (3).

1. Stream lines in the steady flow of heat.
2. Stream lines in the steady flow of electricity.
3. Stream lines in the motion of an incompressible fluid.
4. Lines of force in gravitational or electrostatic fields.
5. Sections of equipotential cylinders in electromagnetic fields.

For example

in figure 3	for which $\mu_1 = m_1 = 1$	and $\mu_2 = m_2 = -1$,
in figure 4	for which $\mu_1 = 1$	and $\mu_2 = 1$,
in figure 5, 6 (4)	for which $\mu_1 = -1$	and $\mu_2 = 2$,
in figure 7	for which $\mu_1 = 1$	and $\mu_2 = 2$,

the curves shown may be regarded as the stream lines of heat, electricity, or an incompressible fluid from a source at one hub to a source (a sink is a negative source) at the other, the intensities of these sources being as m_1 is to m_2. These curves may also be regarded as the lines of force due to a pair of infinite electrified lines of constant charges per unit length, the lines being perpendicular to the planes of the photographs at the hubs, and the charges being as m_1 is to m_2. Finally, these curves may also be regarded as the right sections of the equipotential cylinders corresponding to a pair of infinitely long wires which carry constant currents proportional to m_1 and m_2, the wires being perpendicular to the plane of the photograph at the pictures of the hubs.

The photographs, Figs. 8, 9, 10, for which $\mu_2 = -\mu_1$, $\mu_2 = \mu_1$, $2\mu_2 = -\mu_1$, respectively, where $\mu_1 = 2 + i$, also represent problems in these various branches of mathematical physics in which, however, the boundary conditions are more complex than in the cases illustrated by figures 3 to 7.

It should be noted that the slots in the wheels shown in figure 2 are not rough representations, but that the two boundaries of each slot are accurately constructed co-polar logarithmic spirals. Therefore the broad white bands in photographs figures 8, 9, and 10 are not mere rough approximations to the curves represented by equation (4_0), but the two boundaries of each band are very accurate representations of these curves. Hence the advantage of slots over spokes.

The following applications are also of interest:

If $\mu_1 = -\mu_2 = m(1 + i\tan\alpha)$, equation ($4_0$) may be written

$$\frac{p}{q} = Ce^{(\varphi - \psi)\cot\alpha},$$

where C is a constant. These curves are called bicircular spirals (**5**). They are shown in photograph figure 8 for $\cot\alpha = 2$, and are the *stereographic projections of the spherical loxodromes* when neither pole is projected to infinity.

It is also interesting to note that just as the radiating straight lines $\varphi = \text{constant}$, the concentric circles $\log r = \text{constant}$, and the logarithmic spirals $r = Ce^{\varphi\cot\alpha}$ [equation (3_0) where $\cot\alpha = \frac{m}{n}$ and C is a constant] are the lines of flow of the continuous hyperbolic, elliptic and loxodromic linear transformations of the complex plane for which the invariant points are 0 and ∞, so *the system of circles* $\varphi - \psi = \textit{constant}$, *the orthogonal system of circles* $\log\frac{p}{q} = \textit{constant}$, *and the bicircular spirals* $\frac{p}{q} = Ce^{(\varphi-\psi)\cot\alpha}$ *are the lines of flow of the continuous hyperbolic, elliptic and loxodromic linear transformations for which the invariant points are* z_1 *and* z_2 (**6**).

References and Notes.

(1) For this special case Theorems I and II were proved by the author in 1896. (See Trans. Ac. sc., St. Louis, Mo., 7, no. 9.) These curves (4_1) are called by Johnson (who derived their Cartesian equations, but did not point out their connection with mathematical physics) *Generalized Strophoids*. (See Amer. jour. math., 3, p. 320.) For other references concerning curves (4_1), see abstract of the author's paper on this subject in the Bulletin of the American Mathematical Society, June 1912, 18, no. 9, p. 435.

In his *Researches in Chemistry and Physics*, p. 292, Faraday describes the phenomenon observed when viewing one carriage wheel obliquely through another, and also that when viewing a rapidly running carriage wheel through a palisade or railing. Beyond stating that the curves in the first case resemble the lines described by iron filings between the poles of a magnet, Faraday does not identify the curves with any particular field of force.

(2) See the exception noted in section 7, p. 202.

(3) Osgood, W. F., *Lehrbuch der Funktionentheorie*. 1907. p. 534.

(4) The mechanism is so built that the distance between centers is adjustable.

(5) Holzmueller, *Stereometrie*, 3, p. 300.

(6) Osgood, W. F., *Lehrbuch der Funktionentheorie*. 1907. pp. 223–227.

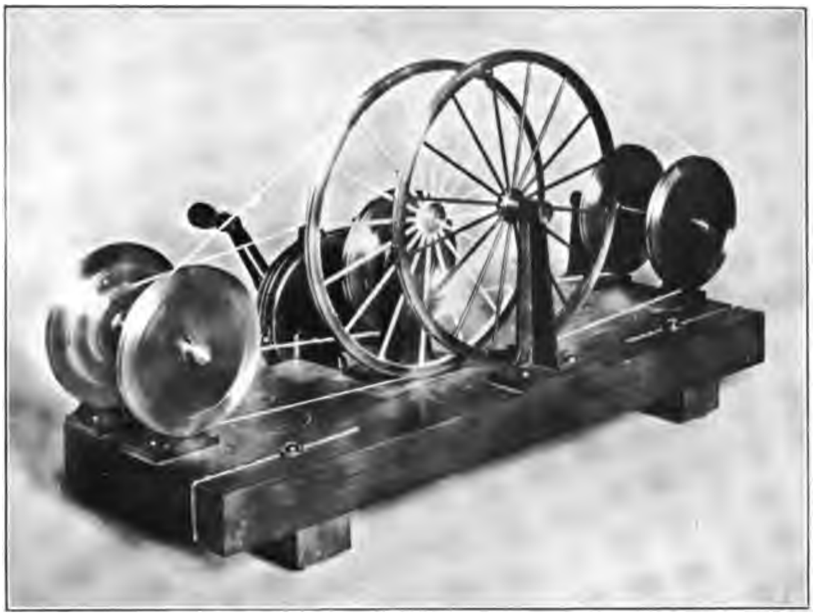


Fig. 1.—A mechanism for illustrating lines of force and stream lines, by spoked wheels.

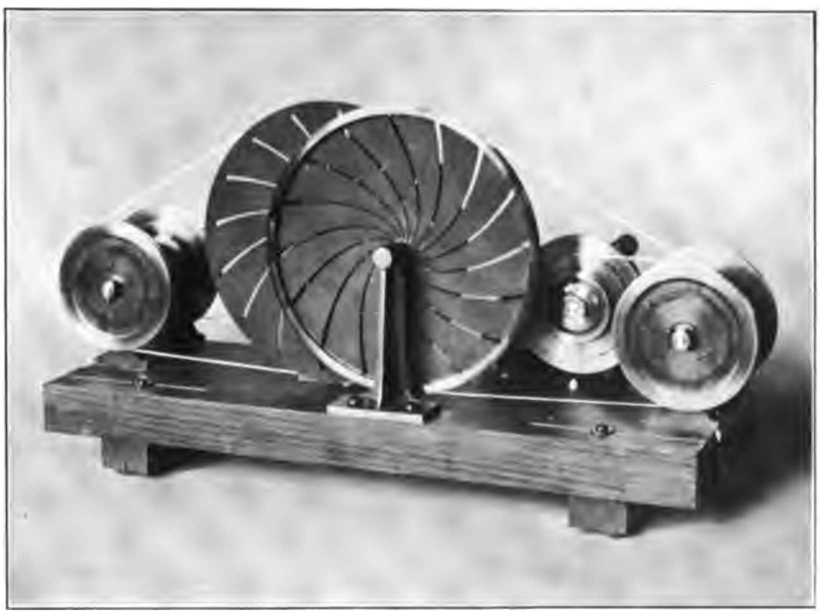
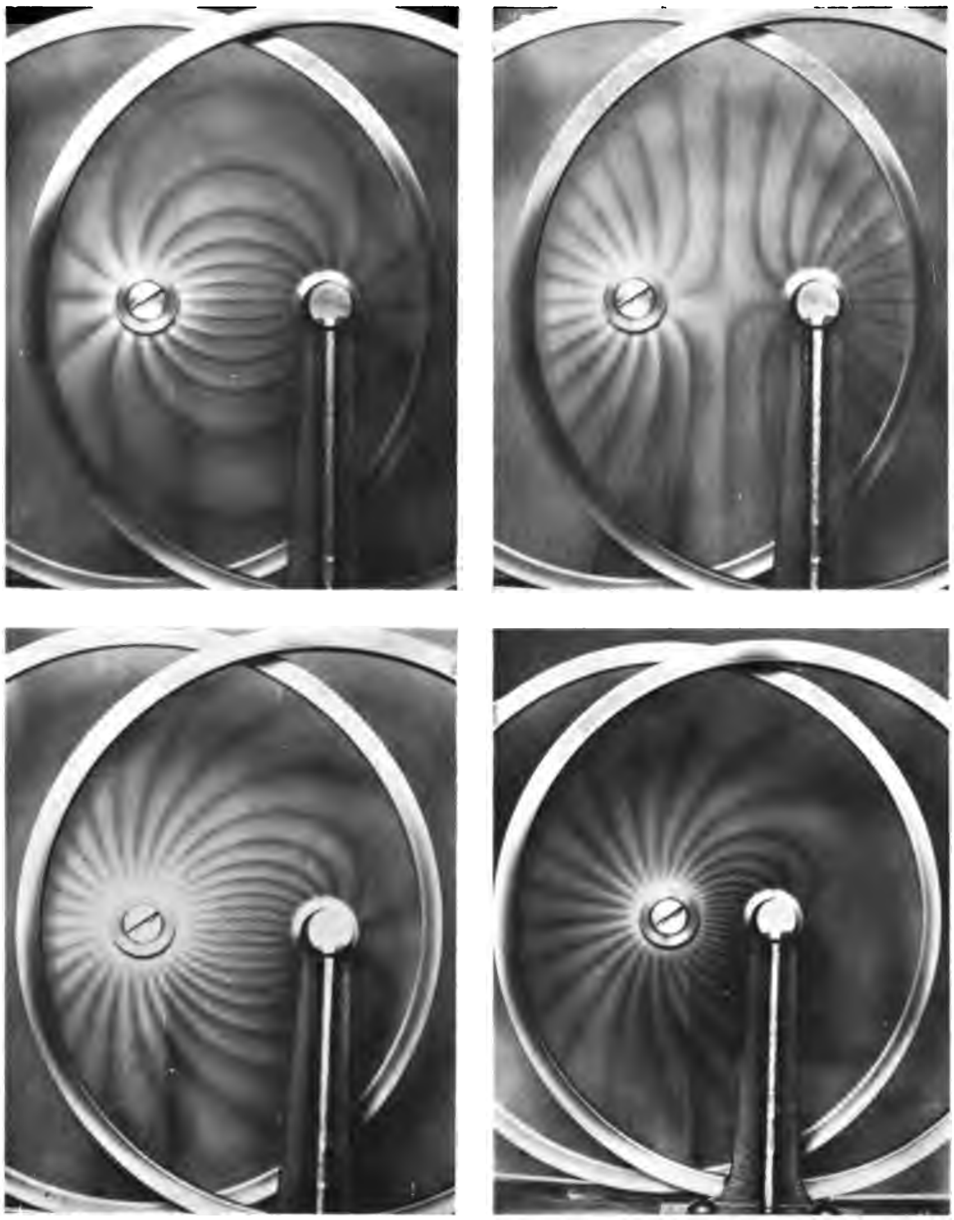


Fig. 2.—A mechanism for illustrating lines of force and stream lines, by slotted webs.

3. 4.



5. 6.

FIGS. 3, 4, 5, and 6.

Photographs of curves produced by Roever's mechanism.

7.

8.

9.

10.

Figs. 7, 8, 9, and 10.

Photographs of curves produced by Roever's mechanism.

11. THE RELATION BETWEEN SOLAR RADIATION INTENSITIES AND THE TEMPERATURE OF THE AIR IN THE NORTHERN HEMISPHERE IN 1912-13.[1]

By Herbert H. Kimball.

[Dated Mount Weather, Va., Feb. 6, 1914.]

The volcanic dust cloud of 1912.—Attention has already been invited in this Bulletin (1) to the diminution in atmospheric transparency which was quite generally observed during the latter part of 1912, and which was attributed, at least in part, to the presence at high levels of great quantities of dust derived from the eruption of Katmai Volcano in Alaska in June, 1912. It will doubtless be recalled that the first violent eruption occurred on June 6, that the dust cloud was first observed at Madison, Wis., on June 8, at Mount Weather, Va., on June 10, at Bassour, Algeria, on June 19, at Mount Wilson, Cal., on June 21, and at various points in Europe between June 20 and June 27.

Direct solar radiation intensities.—In Table 1 are given monthly values of solar radiation intensities measured at Parc Saint Maur, Paris, France (2); Potsdam, Germany (3); Davos, Switzerland (4); Warsaw, Russia (5); Pavlovsk, Russia (6); and Simla, India (7); and also the ratio of these monthly values to the corresponding monthly normals. Midday measurements only have been considered, and for this reason the monthly results are not strictly comparable, since the depletion of solar radiation is relatively greater in the winter months, when the sun is low, than in summer, when it is high. As far as measurements are available, however, they indicate that throughout the northern hemisphere solar radiation intensities were below normal beginning with June or July, 1912, and continuing at least through July, 1913.

In Table 7 are summarized the solar radiation measurements made at Mount Weather, Va., with a Marvin pyrheliometer during 1913. For the method of reducing the observations, see this bulletin, volume 5, part 5, pages 295–311, where observations made previous to 1913 will be found tabulated.

In Table 2 are summarized the measurements made at Mount Weather since May 1, 1912, with the sun at zenith distance, 60°, which is the highest point reached by the sun in December at the latitude of Mount Weather (39° 4′).

[1] Read before the Philosophical Society of Washington, D. C., Feb. 14, 1914.

TABLE 1.—*Midday solar radiation intensities, 1912 and 1913.*

[Gram-calories per minute per cm² of normal surface.]

Month.	Parc St. Maur.		Potsdam.		Davos.		Warsaw.		Pavlovsk.		Simla.	
	Monthly maximum.	Ratio to normal monthly maximum.	Monthly mean.	Ratio to monthly normal.	Monthly mean.	Ratio to monthly normal.	Monthly maximum.	Ratio to normal monthly maximum.	Monthly maximum.	Ratio to normal monthly maximum.	Monthly mean.	Ratio to monthly normal.
1912.												
April	1.23	0.99	......	......	......	......	1.33	1.10	1.35	0.99	1.44	1.01
May	1.20	0.97	......	......	......	......	1.14	0.96	1.39	1.03	1.37	1.00
June	1.27	0.99	0.88	0.66	......	......	1.22	1.02	1.33	1.02	1.22	0.94
July	0.96	0.77	0.85	0.67	......	......	1.00	0.84	1.02	0.81	......	......
August	0.95	0.77	0.80	0.66	......	......	1.00	0.86	1.00	0.80	......	......
September	1.00	0.82	0.72	0.65	......	......	0.89	0.73	0.70	0.56	1.31	0.93
October	1.00	0.85	0.84	0.68	1.19	0.85	0.83	0.74	0.80	0.68	1.30	0.90
November	0.97	1.01	0.71	0.61	1.12	0.84	0.74	0.76	0.52	0.54	1.32	0.90
December	0.75	0.77	0.60	0.68	1.19	0.95	0.67	0.84	0.39	0.51	1.38	0.94
1913.												
January	0.76	0.70	......	......	1.12	0.83	0.75	0.87	0.76	0.81	1.30	0.88
February	1.14	1.03	......	......	1.27	0.89	1.02	0.99	1.01	0.89	1.29	0.88
March	1.09	0.89	......	......	1.31	0.92	1.06	0.96	1.21	0.91	1.34	0.91
April	1.12	0.90	......	......	1.35	0.94	1.19	0.98	1.16	0.85	1.32	0.92
May	1.11	0.90	......	......	1.35	0.93	1.18	0.99	......	......	1.33	0.97
June	1.22	0.95	......	......	1.34	0.96	1.16	0.97	......	......	......	......
July	0.98	0.79	......	......	1.32	0.99	1.15	0.96	......	......	......	......
August	1.22	0.98	......	......	1.30	0.93	1.27	1.09	......	......	1.34	......
September	1.20	0.98	......	......	1.39	0.98	......	......	......	......	1.38	0.98
October	1.09	0.93	......	......	1.34	0.96	......	......	......	......	1.37	0.95
November	0.99	1.03	......	......	1.25	0.95	......	......	......	......	1.40	0.96
December	0.81	0.84	......	......	1.21	0.98	......	......	......	......	......	......

TABLE 2.—*Monthly summary of solar radiation intensities at Mount Weather, Va., with the sun at zenith distance 60°.*

[Gram-calories per minute per cm² of normal surface.]

Month.	Mean.		Maximum.		Ratio to monthly normals.		Mean ration ½ (6+7).
1	2 a. m.	3 p. m.	4 a. m.	5 p. m.	6 Mean.	7 Max.	8
1912.							
May 1–June 9	1.08	1.01	1.25	1.26	1.06	1.15	1.10
June 10–June 30	0.90	....	1.05	1.01	0.86	0.86	0.86
July	0.83	0.88	0.93	0.93	0.86	0.77	0.81
August	0.77	....	0.86	0.75	0.73	0.70	0.71
September	0.89	0.94	1.05	0.97	0.80	0.81	0.81
October	1.03	0.97	1.22	1.24	0.81	0.91	0.86
Nevember	1.14	1.12	1.24	1.17	0.90	0.88	0.89
December	1.26	....	1.33	....	0.97	1.01	0.99
1913.							
January	1.21	....	1.29	1.24	0.90	0.93	0.92
February	1.15	1.13	1.27	1.24	0.91	0.94	0.93
March	1.04	1.05	1.16	1.16	0.85	0.94	0.89
April	0.97	0.88	1.18	1.11	0.79	0.95	0.87
May	0.90	0.82	1.06	0.96	0.87	0.92	0.90
June	0.90	0.93	1.15	1.09	0.89	0.93	0.91
July	0.88	0.87	1.06	1.04	0.88	0.86	0.87
August	0.91	1.04	1.03	1.16	0.93	0.96	0.95
September	1.11	1.06	1.26	1.20	0.95	0.99	0.97
October	1.18	1.12	1.30	1.24	0.87	0.94	0.91
Nevember	1.19	1.17	1.32	1.33	0.94	0.97	0.96
December	1.31	....	1.42	....	1.01	1.08	1.04

The monthly means of measurements made at Mount Weather in the successive years are not strictly comparable, for the reason that since May, 1911, the attempt has been made to obtain measurements whenever the sun was unobscured by clouds, while previous to that time the measurements were made on the best days only, and when there was a prospect of obtaining a series extending over at least two hours. It has therefore seemed best to compute for each month under consideration the ratio between both the mean and the maximum radiation values and the corresponding monthly averages of measurements obtained under normal conditions. The results are given in columns 6 and 7 of Table 2. As might be expected, the ratios based on maximum values, given in column 7, are slightly higher than the ratios based on mean values, given in column 6. I have preferred to use the mean of these two columns, which is given in column 8, to represent the relative intensity of solar radiation at Mount Weather for the respective months, and these values have been plotted as circles in figure 1. The crosses in the same figure represent the relative intensities of solar radiation for Madison, Wis., obtained in a similar manner. The lack of agreement between the results for the two stations for the winter months is partly due to the small number of observations obtained at this season of the year and partly to the effect of smoke at Madison.

Skylight polarization.—In figure 1 are also plotted the monthly mean departures of skylight polarization at Mount Weather, measured at solar distance 90° and in the sun's vertical, with the sun at zenith distance 60°. The observations will be found summarized in Table 3.

The curves that best fit the polarization and the insolation data are very closely in accord. Both show a minimum in August, 1912, a secondary maximum in December, 1912, a secondary minimum in April, 1913, and a gradual return to normal conditions at the end of 1913.

Total radiation.—Measurements of the total radiation received on a horizontal surface have been made at Mount Weather with a Callendar recording pyrheliometer since May, 1912. A comparison of the results for 1912 and 1913, for hours when the sky was cloudless, is given in Table 4. The results for August are omitted, as a different register was used in August, 1913, from that in operation during the other months.

There are not many hours at any season of the year, and especially during the summer, when the sky at Mount Weather is free from clouds. It can therefore only be claimed that the data in Table 4 indicate that with a cloudless sky the total radiation received on a horizontal surface during September and October, 1912, averaged about 5 per cent less than during the same months in 1913, and during November and December, 1912, about 3 per cent less than

during the corresponding period in 1913. From Table 2 it is seen that a similar comparison of the intensities of direct solar radiation gives deficiencies for 1912 twice as great, or 10 per cent in September and October, and 6 per cent in November and December.

The smallness of the ratios for the early morning and late afternoon hours for the first period in Table 4 may be due in part to the fact that less heat was received diffusely from the sky between May 20 and June 9, 1912, than during the same period in 1913. With low sun the amount of heat received diffusely is a considerable part of the

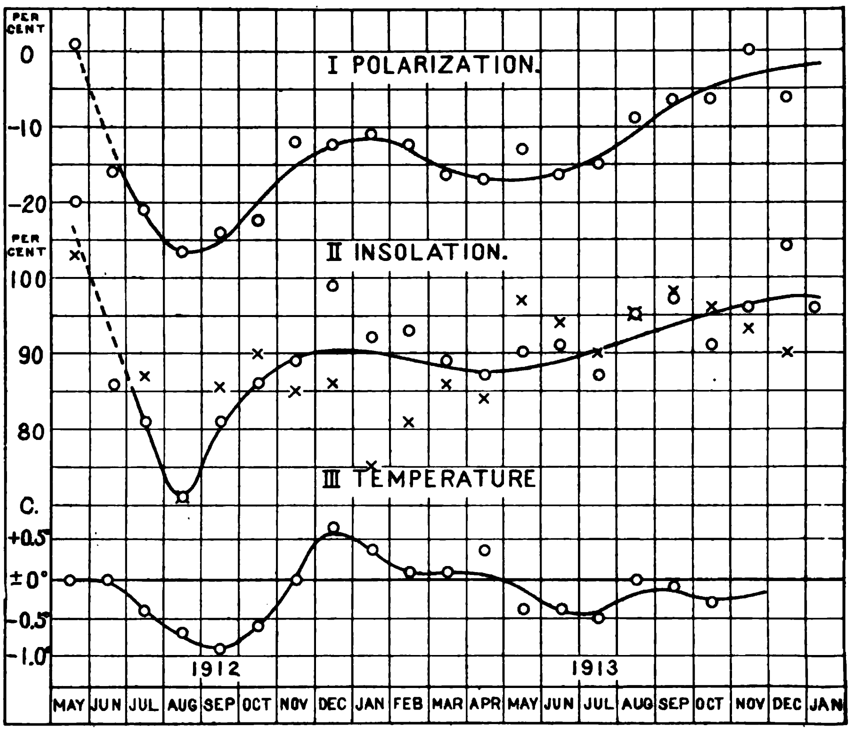


FIG. 1.

Curve I.—Monthly departure of sky light polarization at Mount Weather, Va.
Curve II.—Ratio of observed to normal insolation at Mount Weather, Va. (O), and Madison, Wis. (X).
Curve III.—Monthly temperature departures for the Northern Hemisphere.

whole. The ratios for hours when the sun is low are very irregular, however, partly because of meteorological conditions causing great variations in the quantity of heat received and partly because of the smallness of the quantities measured.

Insolation deficiency.—From figure 1, and from the data in Table 1, it appears that there was a depletion in the quantity of heat energy reaching the surface of the earth throughout most of the Northern Hemisphere during the latter part of 1912, and to a less extent during 1913. The actual deficiency would be less in high latitudes than

in low latitudes, especially in winter. Indeed, from the Arctic Circle northward there would be no depletion of insolation in midwinter from the effects of haze.

TABLE 3.—*Monthly summary of skylight polarization at Mount Weather, Va., in the sun's vertical and at solar distance 90°, with the sun at zenith distance 60°.*

Month.	Percentage of polarization.						Departure from normal.	
	1908	1909	1910	1911	1912	1913	1912	1913
January:								
Mean	58	......	69	......	......	52	......	−12
Maximum	65	......	69	......	......	57	......	−10
February:								
Mean	53	......	71	......	......	46	......	−16
Maximum	54	......	71	......	......	53	......	− 9
March:								
Mean	57	......	67	......	......	44	......	−18
Maximum	61	......	69	......	......	50	......	−15
April:								
Mean	62	62	......	......	......	42	......	−20
Maximum	64	62	......	......	......	49	......	−14
May:								
Mean	58	64	......	48	54	41	− 2	−15
Maximum	61	65	......	56	65	50	+ 4	−11
June:								
Mean	59	......	......	61	42	44	−18	−16
Maximum	64	......	......	70	53	50	−14	−17
July:								
Mean	62	......	......	55	39	44	−19	−14
Maximum	70	......	......	71	47	54	−23	−16
August:								
Mean	61	56	......	59	32	49	−27	−10
Maximum	63	67	......	69	40	58	−26	− 8
September:								
Mean	65	64	......	60	40	56	−23	− 7
Maximum	69	67	......	70	44	63	−25	− 6
October:								
Mean	66	70	......	69	44	57	−24	− 4
Maximum	71	71	......	75	51	63	−21	− 9
November:								
Mean	62	......	......	......	47	58	−15	− 4
Maximum	62	......	......	......	53	66	− 9	+ 4
December:								
Mean	68	......	......	......	52	59	−16	− 9
Maximum	70	......	......	......	61	66	− 9	− 4

TABLE 4.—*Ratio between total radiations, 1912/1913, received on a horizontal surface during cloudless hours at Mount Weather, Va.*

Period.	Hour angle from noon.						
	7–6 6–7	6–5 5–6	5–4 4–5	4–3 3–4	3–2 2–3	2–1 1–2	1–0 0–1
May 20–June 9	0.61	0.87	0.96	0.98	1.04	......	......
June 10–July 31	1.04	1.00	1.05	1.02	0.94	......	......
Sept. 1–Oct. 31	......	1.10	0.96	0.95	0.96	0.94	0.96
Nov. 1–Dec. 31	......	......	0.81	0.98	0.98	0.93	0.99

Temperature deficiency.—Attention has already been invited to a probable connection between the depletion of insolation by volcanic dust and the temperature of the air (8). In Table 5 I have summarized the monthly mean temperature departures for the Northern Hemisphere for the period April, 1912, to October, 1913, inclusive. The data have been derived from the following sources:

Alaska.—Monthly mean temperatures for six Weather Bureau stations were obtained from the monthly summaries of observations, and the corresponding normals from tables prepared by the Climatological Division of the Weather Bureau.

Canada.—The "Temperature differences from the average" for about 140 stations are published in the Canadian Monthly Weather Review. From these were computed the temperature departures for the six districts, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, and Quebec, and the average of these taken for the temperature departure for Canada.

United States.—The temperature departures for 21 districts as published in the Monthly Weather Review have been averaged to obtain the temperature departures for the United States. Observations for about 185 stations are included in this average.

Mexico.—Monthly mean temperatures for seven stations were obtained from the Boletin Mensuel of Mexico, and monthly normals from Hann's Climatology, vol. 2.

Atlantic Ocean.—The temperature departure for Bermuda has been obtained from the Canadian Monthly Weather Review, and for Madeira and the Azores from the Internationaler Dekadenbericht of the Hamburg Seewarte.

Southern Europe, Northwestern Africa, and Asia Minor.—The monthly temperature departures have been computed for 31 stations from temperature data published in the Internationaler Dekadenbericht.

Egypt.—The monthly temperature departures for seven districts are published in the Cairo Scientific Journal, and the mean of these has been taken for the temperature departure for Egypt.

North Atlantic Ocean, northern Europe, and Russia in Asia.—The monthly temperature departures have been computed for 32 station from temperature data published in the Internationaler Dekadenbericht.

India.—The monthly mean temperature departures for 15 districts, representing about 300 temperature stations, are published in the Indian Monthly Weather Review, and the mean of these has been taken for the temperature departure for India.

Hongkong and Manila.—The monthly mean temperatures and monthly normals for Hongkong are published in an abstract from the Monthly Metereological Bulletin of the Royal Observatory, Hongkong; and for Manila in the Philippine Monthly Weather Review.

Japan and China.—The monthly mean temperature departure has been computed from temperature data for about 127 stations published in the Monthly Report of the Central Meteorological Observatory of Japan. The area covered extends from Formosa on the south, lat. 22° N., long. 121° E., to Sakhalin on the north, lat. 49°

N., east to long. 148° E., and west over Korea and eastern China, as far as Tientsin and Hangkow.

Honolulu.—The temperature departures at Honolulu are given in the monthly summary of observations for the U. S. Weather Bureau station at Honolulu (Form 1030–Metl).

Nearly 900 stations are represented in these temperature data. They cover practically all the great land masses of the northern hemisphere, except the interior of Asia, and many of the islands of the sea.

Insolation and temperature data for the southern hemisphere for for this period are not yet available to me.

Since the 12 geographical divisions represented in Table 5 are not of uniform size and the temperature stations are not uniformly distributed, their respective temperature departures have been weighted, as indicated, in computing the temperature departures for the whole hemisphere for each month. The results are given in the last column but one of Table 5, and are plotted in figure 1.

TABLE 5.—*Temperature departures (° C.) for the Northern Hemisphere in 1912 and 1913.*

Districts.	Alaska.	Canada.	United States.	Mexico.	Atlantic Ocean.	NW. Africa, S. Europe, Asia Minor.	Egypt.	N. Atlantic, N. Europe, Siberia.	India.	Hongkong, Manila.	Japan, China.	Honolulu.	Weighted means, dense haze area.	Weighted means, northern hemisphere.	Mountain stations.
Relative weights:	2	5	10	2	2	10	5	10	5	1	5	1			
1912.															
April........	+3.5	+0.7	+0.1	+1.1	−0.8	−1.2	±0.0	−0.1	−0.4	−0.2	+0.2	−0.3	.....	±0.0	−1.7
May..........	+1.2	+0.6	+0.4	−0.1	−0.3	−0.5	−0.3	−0.1	+0.4	+0.8	−0.2	−0.2	.....	±0.0	+0.7
June.........	−1.0	+0.9	−0.8	−1.8	−0.2	±0.0	−0.1	+0.6	+1.2	+0.6	±0.0	−0.4	−0.5	±0.0	−0.1
July.........	−0.5	−1.1	−0.3	−0.6	−1.3	−1.1	−0.4	−0.1	+0.3	+0.6	−0.1	−0.3	−0.7	−0.4	−0.2
August.......	−1.0	−0.9	−0.6	−0.2	−0.7	−1.5	−0.4	−0.8	±0.0	−0.2	+0.1	−0.2	−0.8	−0.7	−3.6
September...	−0.1	−0.9	−0.3	(+0.2)	−0.7	−2.4	−0.4	−1.3	−0.2	−0.3	−1.2	+0.1	−1.0	−0.9	−4.9
October.....	+0.3	−0.1	+0.4	(+0.2)	−0.4	−1.6	−0.3	−2.0	+0.1	−0.3	−0.7	+0.7	−1.1	−0.6	−1.2
November...	+1.9	+2.2	+1.2	−1.9	−0.3	−0.9	−0.1	−0.3	−0.3	−0.1	−1.6	+0.2	−0.6	±0.0	−2.8
December...	−0.6	+1.9	+0.9	+0.5	−0.2	+1.4	−0.5	+1.5	−0.3	−0.6	−0.6	−1.0	.....	+0.7	+3.1
1913.															
January.....	−4.2	−0.9	+1.4	+0.5	+0.3	+1.7	−0.2	+1.1	±0.0	−0.3	−1.1	.....	.....	+0.4	+1.4
February....	+7.7	−0.8	−1.1	+0.4	+0.1	−0.4	−0.9	+0.7	+0.3	+0.4	+0.4	−0.2	.....	+0.1	+0.6
March.......	+1.6	−0.1	−0.2	−1.2	+0.1	+1.1	−1.8	+1.6	−1.5	−0.4	−0.9	+0.6	.....	+0.1	+2.5
April........	+0.1	+1.9	+0.5	−2.7	−1.2	−0.3	−0.2	+0.9	+0.5	−0.2	+1.0	−0.2	.....	+0.3	±0.0
May..........	+0.1	−0.8	−0.1	−1.8	−0.8	−0.6	−1.0	±0.0	−0.3	−0.4	−0.5	−0.1	.....	−0.4	+0.4
June.........	+0.9	+0.7	−0.1	−2.0	−0.7	−0.9	−1.2	−0.4	−0.7	±0.0	−0.4	−0.3	.....	−0.4	−0.7
July.........	−0.7	−0.7	+0.1	....	−0.9	−1.9	−0.3	−0.1	−0.2	+0.5	−0.8	+0.2	.....	−0.6	−1.8
August......	−0.6	+0.7	+1.1	....	−1.1	−1.1	−0.3	+0.1	±0.0	−0.3	−0.9	−0.4	.....	−0.1	−1.4
September...	−1.3	+0.3	−0.1	....	−1.1	−0.3	+0.5	±0.0	+0.2	−0.1	.....	+0.3	.....	−0.1	−0.4
October.....	−0.9	−0.7	−0.4	....	−0.7	±0.0	±0.0	−0.4	+0.7	−0.4	.....	+0.8	.....	−0.2	−1.2
Means, beginning of haze to Oct. 31, 1913.......	+0.1	±0.0	+0.1	−0.8	−0.6	−0.5	−0.5	±0.0	−0.1	−0.2	−0.6	±0.0	.....	*−0.16	−0.6

* June, 1912, to October, 1913, inclusive.

It will be seen that there was a fall from normal temperature conditions in April to June, inclusive, 1912, to 0.9° C. below normal in

September, 1912, followed by a rise to 0.7° C. above normal in December, 1912, and a fall again to 0.6° C. below normal in July, 1913.

The temperature departures are not of the same character in all geographical districts. Generally speaking, all districts were cold during July, August, and September, 1912, except in eastern and southern Asia, where the fall in temperature was not pronounced until September. Indeed, we may trace the gradual eastward progress of the front of the area of low temperature as follows: In Alaska, the United States, and Mexico, in June; Canada, in July; over the Atlantic Ocean, in July; over Europe, during the first decade in July; over Egypt, in July; over Asiatic Russia to longitude 105° E., during the first decade in August; over eastern Asia, in September. The fall in temperature can not be followed across the Pacific Ocean with the limited data available.

In Table 5 black-face figures indicate the temperature departures for those months during which it is believed the different geographical districts were under the densest part of the volcanic dust cloud, and the weighted means of these departures are given in the third column from the last. While these means may more nearly represent the effect of the volcanic dust cloud upon atmospheric temperatures during the first few months following the eruption than do the means for the whole hemisphere, I have refrained from using them in figure 1 because of the uncertainty as to the rate at which the dust was distributed horizontally throughout the atmosphere.

The most northerly districts were generally warmer than the average during the winter of 1912–13. Egypt, eastern Asia, and the southwestern part of the United States were cold throughout practically the entire period.

The average monthly temperature departures for six mountain stations in Europe have been computed from data published in the Internationaler Dekadenbericht (Hamburg), and are given in the last column of Table 5. They show a greater difference between summer and winter departures than is found at high latitude stations.

I have also computed the temperature departures for continental stations of the Northern Hemisphere. The principal deviation from the results given in Table 5 is the accentuation of the difference between summer and winter temperature departures. Thus, while the mean departure for June, 1912, to October, 1913, inclusive, was found to be −0.18° C. as compared with −0.16° C. from Table 5, the departure for October, 1912, was −1.2° C., and for December, 1912, it was +1.0° C., or in each case 0.3° C. greater than in Table 5. The greatest average daily deficiency of temperature for any extended district was 3.6° C. for northern Europe and Asia, or practically the Russian Empire, during October, 1912. In March, 1913, the same region had an average daily temperature excess of 2.8° C.

Several explanations may be offered for the excess of temperature in high latitudes during the winter of 1912–13. The following are probably the most plausible:

1. A period of minimum sun spots prevailed during the years 1912–13, and according to the investigations of Nordman, Abbot, and others, the average temperatures should then be above normal (9).

2. The dust cloud may have acted as a blanket to retard the usual winter cooling of the earth's surface. Humphreys (10) and A. Ångström (11) are of the opinion that the retardation from this source would be slight, but Abbot and Fowle (8) advance arguments to show that half the loss of insolation on account of volcanic haze may have been compensated by a diminution in the radiation from the earth outward, due likewise to the haze.

3. Since insolation initiates both the general and the local atmospheric circulations, the diminution in insolation may have modified the circulation in such a way as to increase the temperature of land masses in high latitudes during the winter of 1912–13.

This last assumption is not improbable, as may be seen from an examination of the temperature departures for the United States. These were generally negative for all districts during June, July, and August, 1912; but in September, when the southwestern part of the United States was experiencing its maximum deficiency of temperature, averaging nearly 3.0° C. per day, the northeastern part of the country began to show a temperature excess. This excess reached its maximum in January, 1913, with an average daily departure for the month of +5.7° C. in New England and the North Atlantic States. These high temperatures, which were almost unprecedented, have been attributed to unusually high barometric pressure over the western Atlantic Ocean, which caused a preponderance of southerly winds over the eastern part of the United States (12).

A second notably warm period occurred in the central Plains States in August, 1913, with average daily temperature departures of +3.7° C. in the Missouri Valley. Persistent southerly winds, low absolute humidity, an almost total absence of rain, and an excess of sunshine have been given as the combined causes of the temperature excess of this period (13).

At the same time Table 6 shows that the monthly temperature departures for the United States for the eight years 1906–1913, inclusive, computed as explained on page 210, indicate that throughout this interval, with the exception of the year 1912, the tendency was for temperatures above the normal, especially during the cold part of the year. This is in accord with the investigations of Arctowski (14), who found the temperatures of New York and of other cities in the eastern part of the United States to be generally above normal in 1905 to 1910, and the investigations of Humphreys (15),

whose temperature curve for the world shows temperatures above normal for the period 1905 to 1911.

TABLE 6.—*Temperature departures for the United States* (°*F.*).

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1906	+5.0	+1.3	−3.4	+1.8	−0.5	−0.7	−0.4	+0.8	+2.3	±0.0	+0.2	+1.1	+0.6
1907	+1.9	+2.0	+4.6	−3.2	−3.9	−2.2	−0.3	−0.7	+0.1	+0.4	+0.8	+2.5	+0.2
1908	+3.5	±0.0	+3.4	+1.8	−1.1	−1.2	+0.3	−0.7	+1.5	−0.5	+2.1	+1.1	+0.8
1909	+3.2	+3.1	+0.2	−1.3	−1.9	+0.3	−0.7	+1.1	+0.1	±0.0	+4.2	−5.7	+0.2
1910	+1.0	−2.2	+8.5	+2.7	−1.1	−0.4	+0.8	−0.4	+1.0	+2.5	−0.1	−1.0	+0.9
1911	+3.8	+1.5	+3.1	−0.6	+1.2	+1.7	−0.2	−0.4	+1.5	+0.4	−2.5	+1.1	+0.9
1912	−3.8	−1.1	−3.8	+0.2	+0.6	−1.5	−0.6	−1.1	−0.5	+0.7	+2.1	+1.7	−0.6
1913	+2.6	−2.0	−0.4	+0.9	−0.1	−0.1	+0.2	+1.9	−0.2	−0.8	+4.2	+1.9	+0.7
Means	+2.2	+0.3	+1.5	+0.3	−0.8	−0.5	−0.1	+0.1	+0.7	+0.3	+1.4	+0.3	+0.5

Conclusions.—The deficiency in insolation in 1912–13 slightly reduced the temperature of the Northern Hemisphere as a whole. It was no doubt a contributing cause of the pronounced low temperature area that advanced eastward from North America in June to September, 1912, to eastern Asia in September to November, 1912, and which persisted about a year in certain regions in low latitudes that are little disturbed by storms. In regions in middle latitudes where storms are frequent local temperature departures were determined largely by the character of the atmospheric circulation.

SUMMARY.

Following the eruption of Katmai Volcano, in Alaska, in June, 1912, a cloud of high haze or dust was gradually distributed throughout the atmosphere of the northern hemisphere and caused a marked diminution in the intensity of direct solar radiation. This diminution reached its maximum at Mount Weather, Va., in August, 1912, and was noticeable until nearly the end of 1913. There was at the same time an increase in the quantity of heat received diffusely from the sky, but the net result was a decrease in the amount of heat energy received at the surface of the earth. It is possible that a decreased rate of outward radiation partly compensated for this loss of insolation.

Temperatures below the normal commenced to prevail throughout Alaska, the United States, and Mexico in June, 1912; over Canada, the Atlantic Ocean, Europe, and northern Africa in July. 1912; over Asiatic Russia to latitude 105° E. in August, 1912; and over the eastern part of Asia in September, 1912. Low temperatures persisted generally in low latitudes during the remainder of 1912 and throughout the summer of 1913, with a maximum deficiency for the whole hemisphere of 0.9° C. in September, 1912. There was an excess of temperature in high latitudes during the winter of 1912–13, with a maximum departure for the hemisphere of +0.7° C. in December. The average daily deficiency of temperature for the

whole Northern Hemisphere for the period June, 1912, to October, 1913, inclusive, was 0.16° C. If we consider continental stations only, the average daily deficiency for this period amounts to 0.18° C.

During the winter of 1912–13 a period of marked excess of temperature prevailed over the northeastern part of the United States. This has been attributed to persistent southerly winds blowing out from an abnormal high-pressure area over the western Atlantic Ocean. During the summer of 1913 an area of unusually high temperature prevailed over the central part of the United States, which has been attributed to persistent dry southerly winds, with an excess of sunshine and an absence of rainfall. It therefore becomes apparent that while a diminution in insolation has had a cooling effect on the temperature of the Northern Hemisphere as a whole, and in regions little affected by storms may have controlled the temperature conditions, yet in regions where storms are frequent and the atmospheric circulation is vigorous this circulation has determined the character of the local temperature, and in some cases has brought it above the normal rather than below. Possibly a decreased rate of outward radiation also has helped to maintain temperatures above the normal in winter in high latitudes, but additional measurements of nocturnal radiation are necessary before this point can be settled.

TABLE 7.—*Solar radiation intensities at Mount Weather, Va., during 1913.*

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Air masses.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1913.											
Jan. 2, a. m.	......	......	......	1.12	1.02	0.89	......	......	......	......	......
Jan. 4, a. m.	......	......	1.20	1.12	......	......	......	......	......	......	......
Jan. 9, a. m.	......	......	1.29	1.21	1.11	1.04	0.97	0.91	......	......	......
Jan. 22, a. m.	......	......	1.28	1.16	1.05	0.97	0.89	0.83	0.76	0.69	......
Jan. 28, a. m.	......	......	1.11	......	0.84	......	0.70	0.62	0.57	......	......
Jan. 30, a. m.	......	......	1.19	1.13	1.00	0.92	0.86	0.80	0.73	0.73	......
Means	......	......	1.21	1.15	1.00	0.96	0.86	0.79	0.69	(0.71)	......
Jan. 4, p. m.	......	......	......	1.04	......	......	......	......	......	......	......
Jan. 9, p. m.	......	......	......	1.15	1.04	0.99	0.91	0.83	0.78	0.73	......
Jan. 21, p. m.	......	......	1.23	1.19	1.03	0.95	0.86	0.82	0.75	0.69	......
Jan. 22, p. m.	......	......	1.24	1.16	1.06	0.99	0.90	0.85	0.81	0.75	......
Means	......	......	(1.24)	1.14	1.04	0.98	0.89	0.83	0.78	0.72	......
Feb. 1, a. m.	......	......	1.12	1.07	......	......	......	......	......	......	......
Feb. 4, a. m.	......	......	1.06	0.94	0.86	0.80	0.73	0.62	0.56	0.52	......
Feb. 5, a. m.	......	......	1.20	1.08	0.93	0.85	0.74	0.64	0.56	......	......
Feb. 6, a. m.	......	......	1.24	1.18	1.09	1.00	0.91	0.84	0.76	......	......
Feb. 7, a. m.	......	1.28	1.16	1.04	0.93	0.86	0.78	0.73	0.64	0.60	......
Feb. 10, a. m.	......	......	......	......	0.81	......	0.67	0.60	0.52	......	......
Feb. 12, a. m.	......	1.21	1.21	1.05	0.93	0.87	0.73	......	......	......	......
Feb. 13, a. m.	......	1.35	1.27	1.21	......	0.97	0.85	0.80	0.75	0.69	......
Feb. 14, a. m.	......	1.30	1.18	1.06	0.95	0.90	0.81	......	......	......	......
Feb. 15, a. m.	......	1.24	1.10	1.00	0.89	0.83	0.75	0.69	0.63	......	......
Feb. 18, a. m.	......	......	1.18	1.01	0.86	0.83	0.71	0.63	......	......	......
Feb. 19, a. m.	......	0.96	0.90	0.81	0.76	0.73	0.64	0.57	0.54	......	......
Feb. 23, a. m.	......	......	1.17	1.05	0.93	0.86	0.79	......	......	......	......
Means	......	1.22	1.15	1.04	0.90	0.86	0.76	0.68	0.62	0.60	......

TABLE 7.—*Solar radiation intensities at Mount Weather, Va.*—Continued.

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Air masses.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1913.											
Feb. 4, p. m			1.08	1.01	0.87	0.76					
Feb. 5, p. m			1.24	1.11	1.02	0.89	0.79	0.71	0.66		
Feb. 6, p. m			1.24	1.13	1.03	0.95	0.87	0.80	0.74	0.69	
Feb. 7, p. m			1.16	1.04	0.94	0.83	0.75	0.71	0.62	0.58	
Feb. 8, p. m			1.21	1.04	0.91	0.83	0.78				
Feb. 12, p. m			1.12		0.83						
Feb. 13, p. m			1.21	1.02							
Feb. 14, p. m			1.16	1.00	0.88	0.79	0.71	0.65	0.59	0.54	
Feb. 18, p. m			1.11	0.96	0.83	0.75	0.69	0.63	0.62	0.58	
Feb. 19, p. m			0.77		0.51	0.44	0.40	0.34	0.32	0.28	
Feb. 22, p. m					0.87	0.76	0.65	0.57	0.50		
Feb. 23, p. m				0.97	0.87	0.80	0.72				
Means			1.13	1.03	0.87	0.78	0.71	0.63	0.58	0.53	
Mar. 7, a. m		1.20	1.09	0.98	0.87	0.79	0.69				
Mar. 9, a. m					0.84	0.76	0.67		0.64		
Mar. 17, a. m		1.27									
Mar. 18, a. m		1.29	1.16	1.03	0.93	0.83	0.76	0.69	0.62	0.54	
Mar. 19, a. m		1.19	1.07	0.96	0.89	0.81				0.56	
Mar. 22, a. m		1.34									
Mar. 28, a. m		1.21	1.04	0.86	0.72	0.63	0.56	0.49	0.44	0.38	
Mar. 29, a. m								0.49	0.42	0.36	
Mar. 30, a. m			0.85					0.47	0.42	0.37	
Means		1.25	1.04	0.96	0.85	0.76	0.67	0.54	0.51	0.44	
Mar. 7, p. m		1.15	1.05	0.97	0.83	0.78	0.70	0.62	0.58		
Mar. 11, p. m		0.91									
Mar. 12, p. m		0.92	0.77	0.63	0.59	0.55					
Mar. 17, p. m		1.28	1.11	1.00	0.89	0.81	0.73	0.65	0.58	0.54	
Mar. 18, p. m		1.29	1.16	1.03	0.93	0.84	0.78	0.71	0.65	0.60	
Mar. 20, p. m						0.78	0.71	0.63	0.58	0.54	
Mar. 21, p. m			1.12	0.97	0.85	0.75	0.64	0.57	0.51		
Mar. 22, p. m		1.30	1.16								
Mar. 27, p. m		1.25									
Mar. 28, p. m		1.13									
Mar. 31, p. m			0.98	0.83	0.72						
Means		1.15	1.05	0.90	0.80	0.75	0.71	0.64	0.58	0.56	
Apr. 1, a. m				0.93							
Apr. 2, a. m		1.16	1.02	0.85	0.76	0.67	0.60	0.54	0.49		
Apr. 3, a. m		1.04	0.85	0.73							
Apr. 5, a. m	1.35	1.24	1.12								
Apr. 7, a. m	1.43	1.26									
Apr. 8, a. m	1.38	1.24	1.11	0.99	0.90	0.83	0.75	0.69	0.63	0.59	
Apr. 17, a. m	1.40	1.28	1.18	1.06	0.95	0.86	0.81	0.74			
Apr. 18, a. m	1.41	1.12	0.99	0.85	0.76	0.66	0.59	0.52	0.49	0.45	
Apr. 20, a. m	1.44	1.29	1.16	1.03	0.93	0.84	0.78	0.66	0.61	0.57	
Apr. 21, a. m	1.40	1.23	1.07	0.94	0.83	0.75	0.69	0.62	0.55	0.50	
Apr. 22, a. m		1.17	1.00	0.85							
Apr. 23, a. m	1.06	0.88	0.70								
Apr. 24, a. m		0.87	0.71	0.56	0.47	0.39					
Apr. 25, a. m	0.98	0.73	0.55	0.46	0.38	0.32	0.28	0.24			
Apr. 30, a. m	1.42	1.27	1.12	0.99	0.89	0.80	0.72	0.64	0.58	0.52	
Means	1.33	1.13	0.97	0.85	0.76	0.68	0.65	0.58	0.56	0.53	
Apr. 8, p. m		1.22	1.01	0.73	0.53						
Apr. 17, p. m		1.25	1.11	0.99	0.89	0.81	0.75	0.69			
Apr. 18, p. m		1.09	0.87	0.75	0.64	0.55	0.47				
Apr. 19, p. m	1.05	0.98	0.84	0.70	0.55	0.49	0.47				
Apr. 20, p. m		1.19	0.95	0.84	0.74	0.65	0.57	0.52			
Apr. 21, p. m		1.22	1.09	0.99	0.90	0.83	0.76				
Apr. 22, p. m	1.27	0.96	0.78	0.64	0.56						
Apr. 23, p. m		0.78	0.58								
Apr. 24, p. m		0.76	0.73	0.57	0.48	0.37					
Apr. 25, p. m		0.91	0.79	0.71	0.58	0.53					
Apr. 30, p. m		1.18	0.98	0.85	0.74	0.63				0.36	
Means	(1.16)	1.05	0.88	0.78	0.66	0.61	0.60	(0.60)		(0.36)	

TABLE 7.—*Solar radiation intensities at Mount Weather, Va.*—Continued.

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Air masses.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1913.											
May 1, a. m.	1.27	1.15	1.02	0.91	0.82	0.73	0.65	0.57	0.52	0.48	......
May 2, a. m.	1.33	1.18	1.04	0.94	0.86	0.79	0.72	0.65	0.61	0.56	......
May 3, a. m.	1.22	0.95	0.78	0.64	0.55	0.47	0.39	0.35	......	......	......
May 5, a. m.	1.00	0.79	0.65	......	......	......	......	......	......	......	......
May 8, a. m.	1.31	1.16	1.02	0.92	0.84	0.77	0.70	0.62	0.56	0.52	......
May 9, a. m.	1.08	0.87	0.57	0.50	0.43	0.35	0.29	0.24	0.21	......	......
May 10, a. m.	1.32	......	......	......	......	......	......	......	......	......	......
May 11, a. m.	1.23	1.09	0.99	0.91	0.82	0.75	......	......	......	......	......
May 12, a. m.	1.28	0.99	0.98	0.89	0.79	0.70	0.64	......	......	......	......
May 13, a. m.	1.03	0.89	0.77	......	......	......	......	......	......	......	......
May 19, a. m.	1.31	1.24	......	......	......	......	......	......	......	......	......
May 25, a. m.	1.30	1.19	1.04	0.90	0.81	0.72	0.64	0.59	0.54	......	......
May 26, a. m.	......	0.89	0.69	0.53	0.41	......	......	......	......	......	......
May 29, a. m.	......	......	1.06	0.96	0.86	0.74	0.64	0.58	0.54	......	......
May 31, a. m.	1.28	1.16	1.05	0.96	0.88	0.79	0.72	0.65	0.60	......	......
Means	1.23	1.04	0.90	0.82	0.73	0.68	0.60	0.53	0.51	0.52	......
May 1, p. m.	......	1.11	0.89	0.69	0.48	0.37	......	......	......	......	......
May 2, p. m.	......	1.01	0.89	0.79	0.71	0.59	0.51	0.46	0.41	......	......
May 3, p. m.	......	0.92	0.76	0.61	0.49	0.40	0.34	0.27	0.22	......	......
May 4, p. m.	0.99	0.83	0.70	0.58	0.48	0.41	0.35	0.31	0.27	0.22	......
May 5, p. m.	......	0.82	0.67	0.53	......	......	......	......	......	......	......
May 8, p. m.	......	1.06	0.96	0.83	0.72	0.62	0.55	0.46	......	......	......
May 9, p. m.	......	0.98	......	......	......	......	......	......	......	......	......
May 10, p. m.	......	0.95	0.88	0.70	0.57	0.51	0.45	......	......	......	......
May 11, p. m.	......	0.99	0.83	0.70	......	......	......	......	......	......	......
May 12, p. m.	......	1.05	......	......	......	......	......	......	......	......	......
May 19, p. m.	......	1.02	0.83	0.59	0.46	0.36	0.29	......	......	......	......
May 20, p. m.	1.22	1.09	0.82	0.65	0.41	0.40	0.40	......	......	......	......
Means	(1.10)	0.99	0.82	0.67	0.54	0.46	0.41	0.38	0.30	(0.22)	......
June 3, a. m.	......	0.98	0.75	0.60	0.50	0.44	0.43	0.40	0.36	0.32	......
June 5, a. m.	......	......	1.04	0.94	0.85	0.77	0.70	0.62	......	......	......
June 6, a. m.	......	0.92	0.79	0.73	0.50	......	......	......	......	......	......
June 9, a. m.	1.43	......	......	......	......	......	......	......	......	......	......
June 10, a. m.	1.37	1.24	1.15	1.05	0.96	0.88	0.79	......	......	......	......
June 11, a. m.	1.38	1.25	1.09	0.96	0.84	0.76	0.73	......	......	......	......
June 12, a. m.	1.31	1.19	......	0.95	0.82	......	......	......	......	......	......
June 13, a. m.	1.07	0.87	0.67	0.54	0.44	0.35	0.30	0.26	......	......	......
June 18, a. m.	1.24	0.98	0.83	0.67	......	......	......	......	......	......	......
June 27, a. m.	......	0.88	......	......	......	......	......	......	......	......	......
Means	1.30	1.04	0.90	0.80	0.70	0.64	0.59	0.43	(0.36)	(0.32)	......
June 2, p. m.	1.31	1.17	1.00	0.90	0.80	0.69	......	......	......	......	......
June 3, p. m.	1.19	......	......	......	......	......	......	......	......	......	......
June 4, p. m.	0.84	......	......	......	......	......	......	......	......	......	......
June 6, p. m.	......	0.87	0.75	0.65	0.58	0.51	......	......	......	......	......
June 9, p. m.	1.42	1.25	1.09	0.97	0.91	......	......	......	......	......	......
June 10, p. m.	......	1.15	......	......	......	......	......	......	......	......	......
June 20, p. m.	0.92	0.72	......	......	......	......	......	......	......	......	......
June 30, p. m.	1.01	0.97	0.89	0.80	0.72	......	......	......	......	......	......
Means	1.12	1.02	0.93	0.83	0.75	(0.60)	......	......	......	......	......
July 1, a. m.	......	0.83	......	......	......	......	......	......	......	......	......
July 2, a. m.	......	......	......	......	0.56	0.51	0.46	......	......	......	......
July 3, a. m.	1.18	1.07	0.94	0.82	0.73	0.64	......	......	......	......	......
Jluy 4, a. m.	1.03	0.82	0.69	0.59	0.52	0.49	0.46	0.43	0.40	0.38	......
July 5, a. m.	1.27	1.12	0.96	0.83	0.78	0.74	0.62	0.50	0.41	......	......
July 6, a. m.	......	......	0.95	0.86	0.77	0.70	......	......	......	......	......
July 7, a. m.	......	1.09	1.00	0.91	......	......	......	......	......	......	......
July 8, a. m.	......	0.98	0.86	0.77	0.65	0.60	0.55	......	......	......	......
July 10, a. m.	......	1.05	......	......	......	......	......	......	......	......	......
July 13, a. m.	......	......	1.00	......	......	......	......	......	......	......	......
July 16, a. m.	1.33	1.19	1.06	0.97	0.88	0.80	0.72	0.65	0.60	......	......
July 18, a. m.	......	0.98	......	......	......	......	......	......	......	......	......
July 19, a. m.	......	1.07	......	......	......	......	0.53	......	......	......	......
July 20, a. m.	......	......	......	0.62	0.48	......	......	......	......	......	......
July 21, a. m.	......	1.12	1.01	0.92	0.83	0.75	0.67	0.63	0.58	......	......
July 22, a. m.	......	1.01	0.86	......	......	0.57	0.53	0.49	0.44	0.41	......
July 24, a. m.	1.16	1.05	0.91	......	......	0.64	0.59	0.55	0.49	0.43	......
July 25, a. m.	......	......	1.05	0.87	0.75	0.63	......	......	......	......	......
July 27, a. m.	......	1.18	......	......	......	......	......	......	......	......	......
July 28, a. m.	1.23	0.92	......	......	......	......	0.43	......	......	......	......
July 29, a. m.	1.07	0.83	0.66	0.53	0.43	0.38	0.34	0.30	......	......	......
July 31, a. m.	......	0.61	0.42	0.40	0.33	0.28	0.22	0.19	0.15	0.13	......
Means	1.18	1.00	0.88	0.76	0.64	0.59	0.51	0.47	0.44	0.34	......

TABLE 7.—*Solar radiation intensities at Mount Weather, Va.*—Continued.

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Air masses.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1913.											
July 1, p. m.			0.71	0.58							
July 2, p. m.	1.05										
July 3, p. m.	1.18	1.00	0.82	0.73	0.64						
July 4, p. m.	1.06	0.98	0.90	0.81	0.71						
July 8, p. m.		1.11	0.98	0.86							
July 13, p. m.	1.32						0.72				
July 14, p. m.		1.12									
July 15, p. m.		1.07									
July 16, p. m.		1.17	1.04	0.92							
July 21, p. m.	1.25	1.11									
July 22, p. m.	1.15	0.97	0.82	0.70							
July 23, p. m.			0.81								
Means	1.17	1.07	0.87	0.77	(0.68)		(0.72)				
Aug. 2, a. m.	1.28	1.10	1.00	0.90							
Aug. 3, a. m.		0.93	0.79	0.66	0.57	0.50	0.44	0.39	0.37	0.34	0.32
Aug. 4, a. m.	1.22	1.01									
Aug. 10, a. m.	1.16	1.12									
Aug. 16, a. m.	1.05	0.97	0.82	0.71	0.60	0.54	0.48	0.43	0.38	0.34	
Aug. 17, a. m.	0.71							0.20			
Aug. 18, a. m.			0.66								
Aug. 20, a. m.		1.18	1.03	0.95							
Aug. 21, a. m.	1.32										
Aug. 23, a. m.		1.10	0.92	0.79	0.72	0.59					
Aug. 24, a. m.									0.30	0.24	
Aug. 25, a. m.		1.20	1.00	0.90	0.81	0.73	0.65	0.58	0.52	0.47	0.42
Aug. 26, a. m.		1.07	0.88	0.75	0.64	0.56	0.49				
Aug. 27, a. m.		0.88	0.85	0.79	0.70	0.62	0.54				
Aug. 28, a. m.	1.10	1.07	1.01	0.95	0.88	0.79	0.70	0.69	0.60	0.53	0.47
Aug. 30, a. m.	1.34	1.04									
Aug. 31, a. m.	1.29	1.15	1.02	0.92	0.82	0.74	0.65	0.58	0.53	0.49	
Means	1.16	1.06	0.91	0.83	0.72	0.63	0.56	0.48	0.45	0.40	0.40
Aug. 2, p. m.	1.33										
Aug. 5, p. m.	1.25	1.06	0.91	0.78							
Aug. 15, p. m.	1.10	0.73									
Aug. 18, p. m.	0.91	0.82									
Aug. 20, p. m.	1.35	1.25	1.16	1.07	0.98	0.90	0.82	0.76	0.69		
Aug. 23, p. m.	1.33	1.12	0.95	0.81							
Aug. 25, p. m.	1.43	1.29	1.12	1.02	0.92	0.83	0.76	0.69	0.63	0.57	
Aug. 26, p. m.	1.23										
Means	1.24	1.04	1.04	0.92	(0.95)	(0.86)	(0.79)	(0.72)	(0.66)	(0.57)	
Sept. 1, a. m.		1.07	0.95	0.84	0.75	0.68	0.62	0.56	0.52	0.47	
Sept. 5, a. m.	1.30	1.17	1.07	0.99	0.93	0.86	0.79	0.74	0.68	0.64	0.59
Sept. 6, a. m.	1.27	1.14	1.04	0.92	0.83	0.76	0.69	0.64	0.59	0.55	0.51
Sept. 9, a. m.	1.44	1.32	1.24	1.17	1.10	1.03	0.96	0.91	0.85	0.81	0.75
Sept. 10, a. m.	1.39	1.27	1.16	1.08	0.99	0.92	0.85	0.79	0.74	0.69	0.65
Sept. 11, a. m.	1.35	1.26	1.14								
Sept. 13, a. m.		1.20									
Sept. 22, a m.		1.28	1.20	1.08	0.97						
Sept. 23, a. m.		1.37	1.26	1.16	1.07	0.98	0.90	0.83	0.76	0.72	0.65
Sept. 24, a. m.		1.09	0.90	0.80	0.72	0.64	0.56	0.49	0.43	0.38	0.33
Sept. 25, a. m.		1.11									
Sept. 27, a. m.		1.24	1.10								
Sept. 28, a. m.		1.26	1.11	1.01	0.94	0.88	0.82	0.76	0.71	0.67	0.62
Means	1.35	1.21	1.11	1.01	0.92	0.84	0.77	0.72	0.66	0.62	0.59
Sept. 2, p. m.	1.16	1.07	0.98	0.87	0.78	0.70	0.63	0.57	0.51	0.46	0.41
Sept. 4, p. m.			0.85								
Sept. 5, p. m.		1.17	1.04	0.97	0.88	0.80	0.73	0.68	0.64	0.59	0.55
Sept. 6, p. m.		1.14	1.03	0.93	0.83	0.75	0.69				
Sept. 9, p. m.		1.29	1.20	1.12	1.04	0.97	0.91	0.86	0.81	0.76	0.72
Sept. 10, p. m.		1.25	1.14	1.06							
Sept. 11, p. m.		1.24	1.15	1.06	0.99	0.90	0.81	0.74	0.67	0.60	0.56
Sept. 23, p. m.		1.28	1.16	1.06	0.96	0.87	0.78	0.71	0.65	0.59	
Sept. 24, p. m.		1.09	1.01	0.83							
Sept. 26, p. m.		1.24									
Means	(1.16)	1.20	1.06	0.99	0.91	0.83	0.76	0.71	0.66	0.60	0.56

TABLE 7.—*Solar radiation intensities at Mount Weather, Va.*—Continued.

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Air masses.										
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1913.											
Oct. 4, a. m.	......	1.33	1.21	1.12	1.04	0.97	0.92	0.87	0.82	0.77	0.71
Oct. 5, a. m.	......	1.35	1.24	1.15	1.09	1.03	0.96	0.89	0.84	0.78	0.73
Oct. 6, a. m.	......	......	1.15	1.09	1.03	......	......	......	......	......	......
Oct. 13, a. m	......	......	1.24	1.09	0.97	0.87	......	......	......	......	......
Oct. 14, a. m.	......	1.38	1.30	1.20	1.13	1.07	1.00	0.92	0.87	0.84	0.81
Oct. 16, a. m.	......	1.27	1.16	1.08	1.02	0.94	0.86	0.80	0.74	0.68	0.62
Oct. 22, a. m.	......	......	1.25	1.12	1.07	1.00	0.92	0.84	......	......	......
Oct. 23, a. m.	......	1.23	1.14	1.06	0.97	0.89	0.85	......	......	......	......
Oct. 27, a. m.	......	......	1.17	1.06	0.98	0.92	0.87	......	......	......	......
Oct. 29, a. m.	......	......	1.03	1.01	0.93	0.85	0.77	......	......	......	......
Oct. 30, a. m.	......	1.15	1.08	0.98	......	......	......	......	......	......	......
Means	......	1.28	1.18	1.09	1.02	0.95	0.89	0.86	0.82	0.77	0.72
Oct. 4, p. m.	......	1.32	1.17	1.06	0.98	0.90	0.82	0.75	0.70	0.65	......
Oct. 12, p. m.	......	1.17	1.04	0.95	0.89	0.85	0.81	0.76	0.71	0.65	......
Oct. 13, p. m.	......	......	1.24	1.09	1.02	0.96	0.90	0.84	0.77	0.71	0.67
Oct. 14, p. m.	......	1.34	1.20	1.06	0.96	0.88	0.82	0.78	0.71	0.64	0.57
Oct. 16, p. m.	......	1.21	1.08	0.92	0.80	0.71	0.65	0.56	0.50	0.46	0.41
Oct. 23, p. m.	......	......	1.10	......	......	......	......	......	......	......	......
Oct. 29, p. m.	......	1.10	1.03	......	......	......	......	......	......	......	......
Means	......	1.25	1.12	1.02	0.93	0.86	0.80	0.74	0.68	0.62	0.55
Nov. 4, a. m.	......	1.04	0.91	0.83	......	......	......	......	......	......	......
Nov. 5, a. m.	......	1.39	1.30	1.20	1.13	1.07	1.01	0.95	0.92	......	......
Nov. 6, a. m.	......	1.41	1.32	1.22	1.13	1.06	1.00	0.94	0.88	0.83	0.78
Nov. 7, a. m.	......	......	......	1.19	1.13	1.08	1.02	0.96	0.91	0.85	0.79
Nov. 12, a. m.	......	......	1.24	1.16	......	......	0.89	0.82	0.76	0.70	0.63
Nov. 17, a. m.	......	......	1.22	......	......	......	......	......	......	......	......
Nov. 18, a. m.	......	......	1.29	1.18	1.10	1.03	......	......	......	......	......
Nov. 21, a. m.	......	......	1.03	0.88	......	......	......	......	......	......	......
Nov. 22, a. m.	......	......	......	......	......	......	0.82	0.74	......	......	......
Nov. 24, a. m.	......	......	......	1.18	1.12	1.06	1.01	0.96	0.91	0.86	......
Nov. 25, a. m.	......	......	......	1.14	1.05	0.97	0.92	0.88	0.84	0.75	......
Means	......	1.28	1.19	1.11	1.11	1.04	0.95	0.89	0.87	0.80	0.73
Nov. 3, p. m.	......	......	......	......	......	0.88	0.78	0.71	0.66	0.61	......
Nov. 4, p. m.	......	......	0.91	0.79	0.63	0.51	0.47	0.44	......	......	......
Nov. 5, p. m.	......	......	1.30	1.22	1.14	1.07	1.00	0.95	0.90	0.85	0.81
Nov. 6, p. m.	......	......	1.33	1.24	1.16	1.09	1.04	0.99	0.94	0.89	0.86
Nov. 12, p. m.	......	......	......	......	......	......	......	0.90	0.86	......	......
Nov. 17, p. m.	......	......	1.28	......	......	......	......	......	......	......	......
Nov. 21, p. m.	......	......	1.06	0.96	0.90	0.86	0.82	0.76	0.69	......	......
Nov. 24, p. m.	......	......	1.14	0.91	0.76	0.67	0.58	......	......	......	......
Means	......	......	1.17	1.02	0.92	0.85	0.78	0.79	0.81	0.78	(0.84)
Dec. 2, a. m.	......	......	......	......	1.03	0.97	0.92	0.85	......	......	......
Dec. 4, a. m.	......	......	......	......	......	0.92	0.84	0.79	0.73	0.65	......
Dec. 5, a. m.	......	......	......	1.16	1.13	1.06	0.97	0.91	......	......	......
Dec. 9, a. m.	......	......	1.33	1.23	1.16	1.09	1.03	0.97	......	......	......
Dec. 12, a. m.	......	......	1.39	1.29	1.20	1.13	1.06	1.00	0.95	0.91	0.87
Dec. 13, a. m.	......	......	1.42	1.37	1.31	1.22	1.13	1.05	1.01	0.97	0.93
Dec. 15, a. m.	......	......	1.39	1.30	1.22	1.16	1.08	1.01	0.95	0.90	0.85
Dec. 18, a. m.	......	......	1.17	0.90	0.81	0.80	0.76	0.74	0.69	......	......
Dec. 19, a. m.	......	......	1.17	1.05	0.99	0.93	0.87	0.85	0.82	0.59	......
Means	......	......	1.31	1.19	1.11	1.03	0.96	0.91	0.86	0.80	0.88
Dec. 9, p. m.	......	......	......	1.22	......	......	......	......	......	......	......
Dec. 11, p. m.	......	......	1.29	1.14	1.01	0.90	0.80	0.71	0.60	0.50	......
Dec. 12, p. m.	......	......	......	......	1.18	1.13	1.07	1.02	0.98	......	......
Dec. 13, p. m.	......	......	......	1.27	1.20	1.14	1.08	1.03	1.00	0.93	0.87
Dec. 15, p. m.	......	......	......	1.24	1.21	1.12	1.02	0.94	0.88	0.82	......
Means	......	......	(1.29)	1.22	1.15	1.07	0.99	0.92	0.86	0.75	(0.87)

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12. THE DIURNAL SYSTEM OF CONVECTION. A SUMMARY OF THE FREE AIR DATA OBTAINED AT MOUNT WEATHER FOR THE FISCAL YEAR JULY 1, 1912, TO JUNE 30, 1913.

By the Aerial Section—WM. R. BLAIR, Junior Professor in Charge.

[Dated Mount Weather, Va., April 1, 1914.]

OBSERVATIONS.

Five balloon and 178 kite ascensions were made during this year. The mean of the highest altitudes reached by the balloons was 2,120 meters above sea level; by the kites, 3,048 meters. These ascensions were for the most part made in series, or in attempts at series, of observations continuing for 24 or more hours. The series were for the most part made in clear weather. In all, 11 complete and 9 partial series were made during the year. Partial series of less than 12 hours' duration have not been considered in the summary. Three complete series and one partial series made during the previous year have also been considered, making a total of 14 complete and 10 partial series summarized. These comprise 164 observations by means of kites and 6 by means of balloons. The mean of the highest altitudes reached with the kites was 3,258, but with the balloons 2,022 meters above sea level. The height to which observations were made was limited to 3,500 meters. One observation to this altitude could be made in about 3½ hours.

Opportunities for making a 24-hour series of kite flights to an altitude of 3 to 3.5 kilometers are not frequent, especially in the winter months. In winter the high and low pressure areas pass in such rapid succession that the time between calms or wind changes is not as long as the desired series. A series of 24 hours or longer was made on probably every opportunity that offered during this fiscal year.

The purpose of these observations was the study of the diurnal system of convection. The elements observed were pressure, temperature, humidity, wind, and electric potential. The data have been considered in two groups—(1) observations when the sun was south of the equator and (2) observations when the sun was north of the equator. A more detailed grouping would be of interest, but the number of observations does not warrant it. The complete series have already been considered separately.[1]

The hourly values for any 24 hours of any of the elements observed have been compared with the value of that element at 1 p. m. and

[1] See this BULLETIN, 4, p. 344,418; 5, p. 21, 247, 372; and 6, p. 40, 81.

their departures taken. The value at 1 p. m. was selected because on nearly all days on which observations were made an observation was made at this hour. When the period of observations began after or ended before 1 p. m. values for this hour were estimated. The mean departure of each element for each hour was found for each of the groups and applied to the mean 1 p. m. value. A slight correction was needed to eliminate the 24-hour change indicated by these mean hourly values.

Six levels, one-half kilometer apart, have been considered in each group and the complete data at each level shown in as many charts. The data for the summer group are charted in figures 1 to 6; for the winter group in figures 7 to 12. There are three groups of curves in each figure. The upper group shows the diurnal variation of pressure, temperature, and absolute humidity; the second group, the diurnal variation of wind direction and velocity; and the third, the diurnal variation in atmospheric potential. To the left of each group of curves are given departures from the mean value for the 24 hours; to the right, the observed values of the different elements.

The elements upon which the curves showing diurnal variation in air movement are based need explanation. It is apparent that the small diurnal variation in the value of either the west or the north component of the air movement has but little effect on the whole air movement as observed during the kite flight. The total observed air movement has therefore been resolved into its west and north components and only the diurnal variation in each component, as shown by the hourly departures from the mean value for the day, considered. With these departures as component parts the direction and velocity of the winds belonging to the diurnal convective system have been determined. The hourly values of the direction and velocity thus determined are the ones charted in the second group of curves shown in each figure.

All the elements in either group of data observed at a given level are charted in one figure so that the relations existing among them may be readily apparent. The comparison of the data obtained at any level with those at another, or of those in one group with those of the other, is not so easy since different figures must be consulted. To assist in this comparison a chart, figure 13, has been constructed in which data of both groups at the 526 and at the 2,500 meter levels are shown.

To avoid confusion of lines the data for air pressure, temperature, and movement only have been shown in figure 13. Black lines are drawn through equal departures from the mean of the air pressure. Red lines are similarly drawn for the air temperature. These departures are expressed in millimeters of mercury and in degrees centigrade, respectively. Arrows indicate the hourly direction and (by their

length) velocity of the horizontal air movement belonging to the diurnal convective system. If it were not for the variation in length of day and night the charts in figure 13 as constructed would approximately map conditions at the two levels in a belt around the world between 25° and 50° north of the parallel on which the sun's rays are vertical. The charts do show fairly well the positions of maximum departures from the mean pressure and temperature at either equinox but do not necessarily indicate the correct magnitude of these departures at those times. The primary purpose of drawing the pressure and temperature lines through the equal mean departures found for the cold and for the warm months of the year is to make easily apparent the relative magnitude and position of the departures found in the two halves of the year.

VARIATIONS OF TEMPERATURE.

As shown in figures 1 to 13 the type of diurnal variation prevailing at the earth's surface, in most of the elements observed, extends to between the 1.5 and 2 kilometer levels in the summer half of the year; to between the 1 and 1.5 kilometer levels in the winter half. Above this transition level an entirely different type of diurnal variation in these elements tends to prevail. The temperature, pressure, and movement of the air show these two types of diurnal variation most markedly.

The temperature maximum for the day at the earth's surface is found at $3^h\ 40^m$ p. m. in the summer half of the year. In the higher levels this maximum is somewhat retarded, appearing at 5^h and $5^h\ 30^m$ p. m., respectively, at 1 and 1.5 kilometers. Above the 1.5-kilometer level this maximum is in evidence only as a small secondary maximum superposed upon the diurnal minimum. It appears at 5 p. m. in each of these upper levels.

The temperature minimum for the day at the earth's surface is found at 5 a. m. in the summer half of the year. The advent of this minimum shows very little retardation in the 1 and 1.5 kilometer levels. At levels higher than the 1.5 kilometer this minimum appears at 6 a. m. as a slight secondary minimum superposed upon the diurnal maximum of those levels.

The temperature maximum for the day at the earth's surface is found at 3 p. m. in the winter half of the year. This maximum occurs at $3^h\ 30^m$ p. m. at the 1-kilometer level. At higher levels it appears at 1 to 2 p. m. as a slight secondary maximum superposed upon or as an interruption in the diurnal minimum.

The temperature minimum for the day at the earth's surface is found at $5^h\ 35^m$ a. m. in the winter half of the year. At the 1-kilometer level this minimum is interrupted by a slight secondary maximum of temperature. At higher levels there is little or no trace of it.

In the lower stratum explored, below the transition level defined above, departures of temperature from the mean for the day are greatest at the earth's surface. They gradually decrease with altitude up to the transition level.

Above the transition level the temperature maximum for the day in the summer half of the year is found at 3 to 8 a. m. in the 2- and 3-kilometer levels and at 3 to 11 a. m. in the 2.5-kilometer level. In the 2- and 2.5 kilometer levels this maximum of temperature, as illustrated by the means charted in figures 4 and 5, is not sharp. It seems to show the influence of the diurnal minimum of the lower stratum. In the 3-kilometer level this influence is less and the maximum better defined. At these levels the minimum temperature shown by any one series of observations is usually better defined than that shown by the means of the observations.

The temperature minimum for the day above the transition level tends to place itself immediately above the diurnal maximum of the surface stratum, but is apparently interrupted at all levels in the summer months by the influence of the diurnal maximum of the lower stratum. There are, therefore, in the mean two minima of about equal importance occurring at 1 to 2 and 7 to 8 p. m. In any one series of observations the same type of curve is usually shown at this time of the day, but one or other of the minima is likely to predominate to a greater extent than is indicated by the mean curves.

In the winter half of the year the temperature maximum above the transition level is found between 1 a. m. and 6 a. m. The influence of the diurnal minimum of the lower stratum is apparent at the 1.5- and 2-kilometer but not at the 2.5-kilometer levels. At the 2.5-kilometer level the maximum occurs shortly after 3 a. m.

The temperature minimum for the winter half of the year above the transition level tends to place itself immediately above the maximum of the lower stratum. There is, however, in this as in the summer half of the year a persistent secondary maximum of a few tenths of a degree superposed upon the minimum.

In both halves of the year the decrease in temperature at the earth's surface after the diurnal maximum has passed becomes markedly less at or just before midnight. There is little or no decrease in temperature until after 1 p. m. From this hour on until the minimum is reached the decrease in temperature is fairly rapid.

At the 1-kilometer level a small secondary maximum of temperature appears as an interruption in the primary minimum. At higher levels this secondary maximum becomes more important, until above the transition level it is the principal diurnal maximum.

The type of diurnal variation of temperature obtaining above the transition level is still well defined at the 3-kilometer level in both halves of the year. Observations with sounding balloons will be

made in the near future, having for their purpose the study of diurnal variation of the various meteorological elements at levels higher than 3 kilometers.

VARIATION OF HUMIDITY.

With the exception of the surface and 1-kilometer levels in the summer half of the year and the 2.5 and 3 kilometer levels in the winter half of the year, the maximum moisture content of the air is found shortly after noon and the minimum shortly after midnight at all levels and in all times of the year. At the four levels mentioned the maximum moisture content is found just before noon.

VARIATION OF ELECTRIC POTENTIAL.

The atmospheric electric potential reaches its maximum value for the day at about 7 a. m., i. e., at or soon after sunrise. From this maximum value it falls rather rapidly to its mimimum value at about 1 p. m. From this point there is a slow rise to what in many of the curves, especially those showing diurnal variation in the summer half of the year and at the lower levels, is a secondary maximum an hour or two before or after midnight. Those curves that do not show a secondary minimum about 3 or 4 a. m. have rather flat maxima. The diurnal variation in this element is much greater in the winter than in the summer half of the year at all levels. This element varies fairly consistently with the period of insolation. Hourly departures from the mean value for the day are negative from three or four hours after sunrise until four or five hours after sunset. Departures are positive during the remainder of the 24 hours.

SUGGESTED EXPLANATION OF TEMPERATURE DISTRIBUTION.

The temperature distribution both in the upper and in the lower of the strata considered seems to depend largely upon the varying ability of the latter to absorb and transmit terrestrial radiation. As the sun warms the earth's surface in the morning unequal heating produces local convection, thus causing interchange of surface air with air at higher and higher levels as the warming progresses. A soil thermometer at a depth of 2 centimeters records the highest temperature between 1 and 2 p. m. on a clear day. Nearer the surface the soil temperature maximum occurs earlier. At a depth of 20 centimeters it is found at about 8 p. m. After the earth's surface has reached its maximum temperature it loses heat most rapidly to the air in contact with it by conduction, and to air farther up by convection and by radiation. The heated air at the earth's surface as it rises to higher levels carries with it moisture, dust, and nuclei rendering the stratum into which it rises capable of absorbing more, consequently of transmitting less, of the heat radiated from

the earth's surface. There is some evidence that the action of sunlight renders the air near the earth's surface less diathermanous. As the earth's surface cools the local convective currents subside. The formation of dew or frost, the settling of dust and nuclei, and the absence of the effect of sunlight on nucleation, combine to gradually clear the lower air, rendering it more and more diathermanous until sunrise of the next day. The height to which these local convective currents stir the air near the earth's surface seems to coincide with the transition level or the boundary between the two strata above defined. It is to be expected that the lower stratum will be deeper in the summer than in the winter half of the year.

The diurnal maximum of temperature at the earth's surface is chiefly the result of conduction and of convective mixing, the latter having a retarding influence. In the higher levels of the lower stratum the diurnal maximum of temperature is the result of convection and the absorption of terrestrial radiation. As observed above, the maximum at these levels occurs considerably later than at the earth's surface. The secondary maximum of temperature in the upper stratum occurs at an earlier hour than the primary maximum in the upper part of the lower stratum. It does not lag with altitude. Therefore the chief determining factor of this secondary maximum in the upper stratum seems to be the absorption at these levels of terrestrial radiation that has passed through the lower stratum rather than of radiation from the air of lower levels. The increasing absorbing power of the air in the upper part of the lower stratum together with the decline of the earth's potential as a radiator seems to determine the time of this secondary maximum in the upper stratum.

The diurnal minimum of temperature in the upper stratum is found at about the same time as the diurnal maximum in the lower stratum and is apparently accounted for by the high absorption and low transmission of the air in the lower stratum for terrestrial radiation. A relatively small amount of heat from this source reaches the upper stratum in the afternoon.

The diurnal minimum in the lower stratum is apparently found at the time when the air in this stratum is most diathermanous and when the earth's potential as a radiator is lowest. It is about this time of the day, earlier in the winter half of the year, that the maximum temperature of the upper stratum is found. This upper maximum seems to occur at the time when, the diathermance of the air of the lower stratum and the earth's potential as a radiator considered, a relatively large amount of heat from this source is received in the upper stratum.

It should be noted that the diurnal maximum of temperature in the upper stratum appears at 10 or 11 hours after sunset, this inter-

val being somewhat shorter in the winter than in the summer half of the year. Some observers measuring nocturnal radiation to the sky have found a maximum value at two or three hours before sunrise; others have not found a maximum value. This maximum value of nocturnal radiation seems to occur at the time of the diurnal maximum of temperature of the upper stratum. If these maxima are simultaneous phenomena it is not likely that a nocturnal radiation maximum will be found in the shorter summer nights. On the other hand, such a maximum would be well defined in the long winter nights. Such a maximum would tend to occur at a given time, 10 or 12 hours, after sunset rather than at a given time before sunrise.

The amount of moisture in the upper stratum generally is less at the time of the diurnal maximum of temperature than at the time of the minimum. This condition probably tends to equalize the temperature at these levels.

This suggested explanation of the diurnal distribution of temperature in the region explored is practically the same as the tentative explanation based upon the data obtained in the three series of ascensions made during 1911 and 1912. Since the publication of the tentative explanation (this Bulletin, Vol. IV, p. 344) the author has had the advantage of the criticism of the work by others. For the most part critics have agreed with the explanation given. Some, however, think that practically all terrestrial radiation outside of the limits 8μ to 11μ is absorbed within a kilometer of the earth's surface and that air temperature above this level owes its degree and distribution largely to re-radiation from the air at lower levels.

The observed values of nocturnal radiation vary between 0.12 and 0.20 calories per square centimeter per minute. If the air within a kilometer of the earth's surface absorbs 50 per cent of this radiation it will absorb heat enough to increase its temperature 1° C. in every 3 or 4 minutes. In order to maintain the observed nocturnal air temperature the radiation from the air of this stratum must itself somewhat exceed terrestrial radiation. It is not likely that absorption and radiation of heat by the night air of the lower stratum is at all so rapid as this. Assuming it to be so, a very wide variation in the rate of absorption and radiation by air in the different strata, and by air in a given stratum at different times of day, would be needed to explain the observed temperature distribution. It is hardly probable that, if more were known of the effect of insolation on the air through which solar rays pass, especially of its effect on nucleation, an explanation in accord with the above assumption could be found.

The fact that in the transition level both the after-noon and after-midnight maxima are well defined seems to oppose the idea that

the after-midnight maximum in the upper stratum is the afternoon maximum of the lower stratum, either retarded or accelerated, or that re-radiation from the lower stratum plays any important part in determining the diurnal variation of temperature in the upper stratum.

If the nocturnal barometric maximum is brought about by the vibration of the atmosphere as a whole, the question may be raised as to whether or not the nocturnal temperature distribution is an accompaniment of the pressure distribution. The variation in the time of occurrence of the nocturnal temperature maximum, also the fact that it is found only in the upper stratum and nearly above the minimum temperature of the lower stratum, does not favor this explanation. Moreover, as will be shown later, it is not easy to make the idea of the vibration of the atmosphere as a whole fit the observed diurnal variation of the several meteorological elements at different altitudes.

VARIATIONS OF WIND AND PRESSURE RELATED TO THOSE OF TEMPERATURE.

In general it is noted that the highest wind velocities accompany the maxima and minima of temperature, or any sharp decrease in the rate of increase or decrease of temperature. Changes in wind direction are found at the maxima and minima of air pressure. Maxima of pressure are in general found to follow somewhat minima of temperature and vice versa. This may be explained as follows: Any system of inflow or outflow that is started as a result of the cooling or heating, respectively, of a given air mass, will, if this cooling or heating be sufficiently rapid, reach its maximum intensity at the time when the rate of temperature-decrease or increase falls below a certain value in approaching a minimum or maximum of temperature. If the extreme of the temperature in question be a minimum, a considerable rise in temperature of the air mass under consideration will be needed to check the circulation set up by the immediately preceding fall in temperature. At the time this circulatory system is checked and before, or possibly soon after a counter system of circulation has set in, the air pressure will have reached its maximum value. The air pressure will continue to rise until relieved by the counter system of circulation. In a similar way the minimum of air pressure follows the maximum of temperature.

These interrelations of the temperature, movement, and pressure of the air tend to obtain throughout the region explored by the 24-hour series of kite observations. Conditions in one stratum are influenced by those in the other, and the relations are somewhat less apparent in the upper stratum than they are in the lower. In the absence of other influences the temperature distribution in

the lower stratum would cause a maximum of pressure at 8 to 11 a. m. and a minimum at 3 to 6 p. m. The temperature distribution in the upper stratum would cause a maximum at 8 to 12 p. m. and a minimum at 4 to 8 a. m. A secondary maximum and minimum appear in the lower stratum at the time the principal maximum and minimum tend to appear in the upper and vice versa. In figure 13 the principal maximum for the day in the upper level is still shown near noon. This maximum is but little higher in this level than the maximum occurring at about 10 p. m. and in the 3-kilometer level the latter is the primary maximum. These secondary maxima and the minima together with a possible shift in the position of the primary maximum and minimum in the upper stratum represent the influence of the conditions in one stratum upon those in the other. That the secondary maxima and minima are no more prominent than they actually are is observational proof of the fact that horizontal flow at or but little above the level affected takes care of the expansion and contraction of the air accompanying the diurnal variation in temperature.

Computations, based upon the observations made and in accord with the above explanation, in those regions where the above relations are most apparent not only seem to justify the explanation but also to indicate that practically all expansion and contraction of the air brought about by the diurnal variation of temperature is taken care of by the horizontal flow of air. This is opposed to the idea that the atmosphere is set in vibration as a whole and seems to indicate that the diurnal variation of pressure and the circulation attending it are confined to the comparatively low levels. The idea of atmospheric vibration as a whole resulting from diurnal variation in temperature is further opposed by the fact that mean hourly temperatures of the air up to the 3-kilometer level show a variation from minimum to maximum of only 1.3° C. in the winter half of the year and of 1.7° C. in the summer half. These mean temperatures are shown in Table 1. In view of the fact that there is still a decided diurnal variation in temperature at the 3-kilometer level, it seems highly probable that mean hourly temperatures to, say, 5 kilometers would show but little if any diurnal variation. We shall soon have observations of hourly temperatures to greater altitudes, but without them and based upon the data up to 3 kilometers it appears that the volume expansion or contraction in the lower of the two strata considered would be practically offset by the volume contraction or expansion in the upper. It follows, therefore, that if the horizontal flow did not take care of the diurnal expansion and contraction of the air at or very little higher than the levels affected, there would still be no vertical movement of the atmosphere as a whole and no overflow of air at high levels.

TABLE I.—*Mean hourly temperatues of the air between Mount Weather and the 3-kilometer level.*

Half of year.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.	12 m.
	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.
6 months winter	−1.2	−1.2	−1.1	−1.1	−1.1	−1.3	−1.8	−2.0	−2.1	−1.8	−1.7	−1.4
6 months summer	10.0	10.1	10.2	10.0	9.8	9.9	10.2	10.5	10.6	10.8	10.9	11.0

Half of year.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.	12 m'd't.	Means.
	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.
6 months winter	−1.1	−0.8	−0.8	−1.0	−1.1	−1.1	−1.3	−1.3	−1.3	−1.5	−1.4	−1.4	−1.3
6 months summer	10.9	11.2	11.3	11.5	11.5	11.3	10.9	10.6	10.5	10.5	10.3	10.0	10.6

CONCLUSIONS.

The above observations seem to indicate that the diurnal convective system described exercises practically no disturbing effect on the atmosphere above the 5 or 6 kilometer level, i. e., above the level at which normal atmospheric pressure is half of its value at sea level. The heating effect of direct solar radiation on the air of these lower levels seems to be small compared with that of terrestrial radiation.

Other diurnal effects similar to the one described above may occur at the upper surface of a cloud layer or in those supposed regions of the atmosphere where the constitution of the air is such that it absorbs and is heated to a considerable extent by direct solar radiation. Such effects are no doubt largely confined to those strata of the atmosphere in which the unequal heating occurs.

One concludes from a study of the above data that the diurnal system of convection observed is confined to the lower levels of the atmosphere and does not to an appreciable extent affect the atmosphere as a whole, and that upon the diurnal distribution of temperature depends largely the diurnal distribution of the other elements observed. It is, of course, apparent that the distribution of the other elements in turn influences the distribution of temperature. In the region explored there are two rather distinct types of diurnal variation of temperature. One prevails up to the 1.5-kilometer level (higher in summer than in winter), the other above this level. The diathermance of the lower of these two strata seems to control the temperature variation in both. When the air of the lower stratum absorbs a relatively large percentage of terrestrial radiation its temperature is relatively high and the air temperature of the upper stratum relatively low. When the air of the lower stratum transmits a relatively large amount of terrestrial radiation its temperature is relatively low and the air temperature of the upper stratum relatively high. Radiation from the air in one part of the region explored to that in another part does not seem to have an appreciable effect on the diurnal variation of temperature.

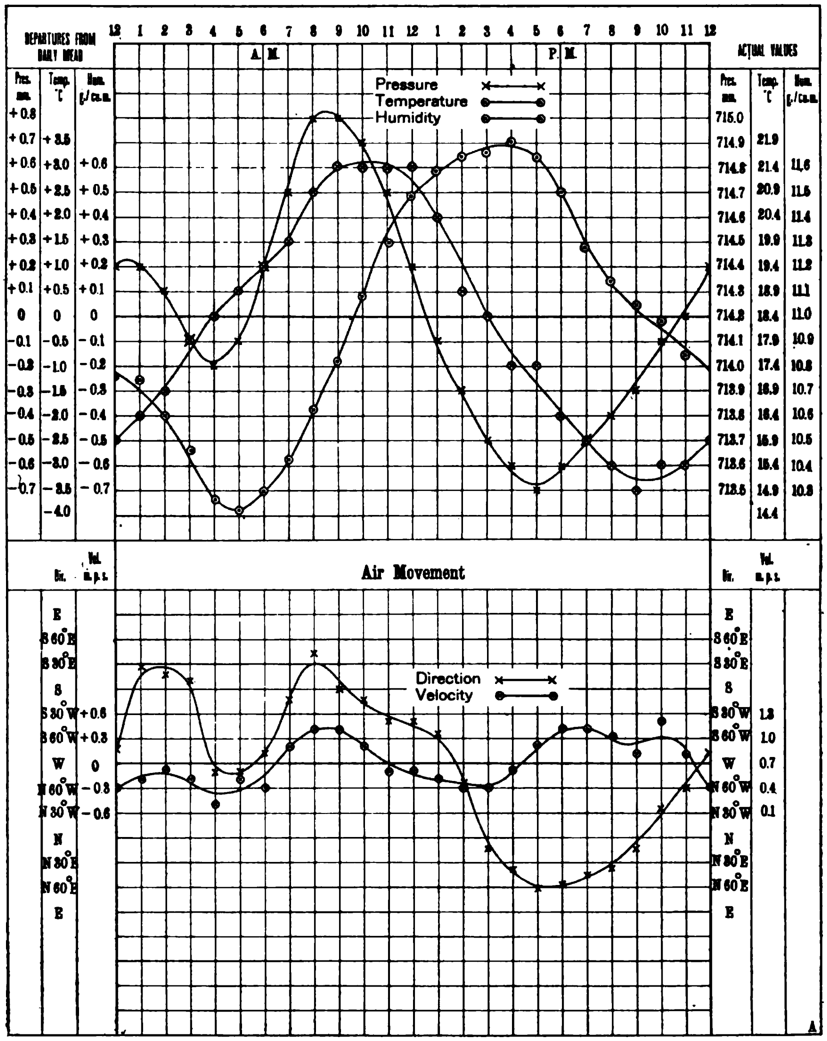

FIG. 1.—April to September mean curves of the diurnal variation at the 526-meter level.

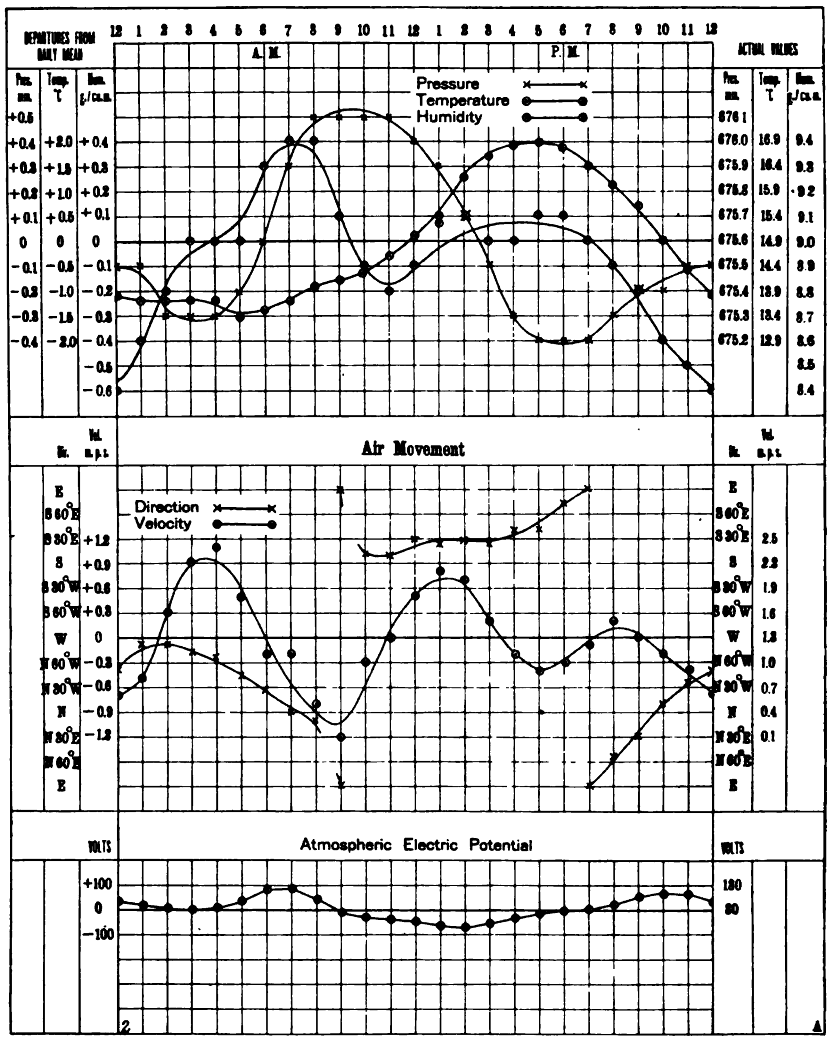

FIG. 2.—April to September mean curves of the diurnal variation at the 1,000-meter level.

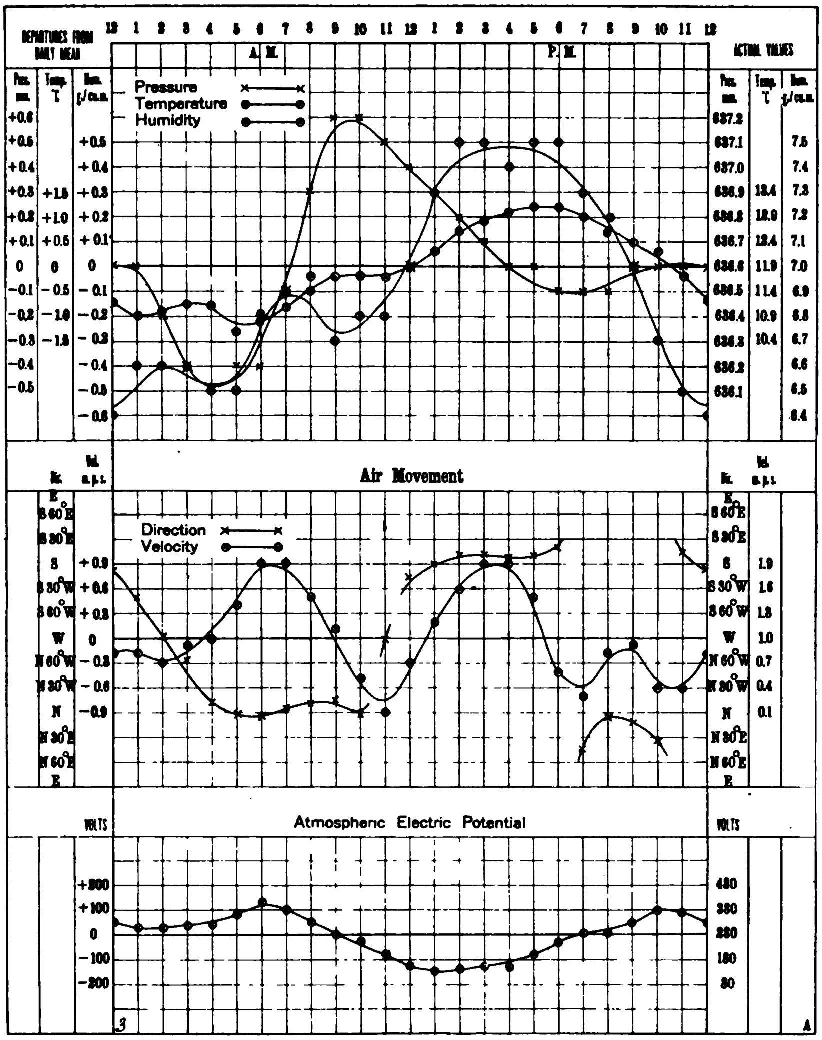

FIG. 3.—April to September mean curves of the diurnal variation at the 1.500-meter level.

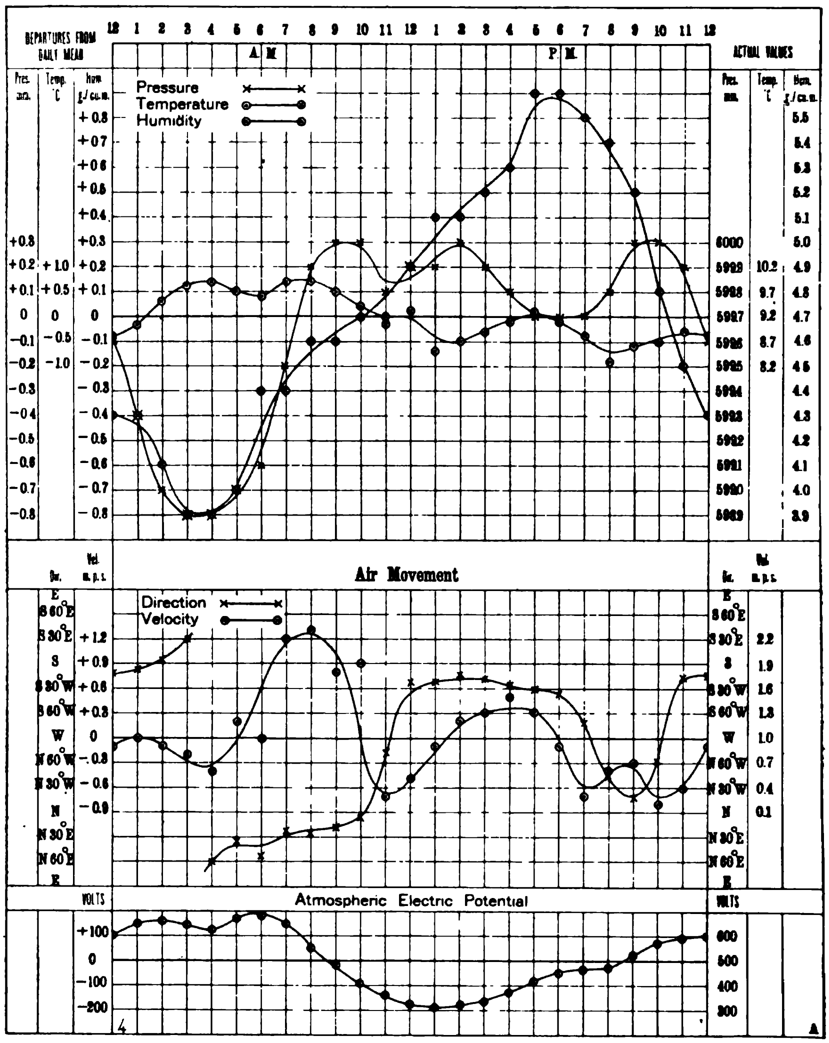

FIG. 4.—April to September mean curves of the diurnal variation at the 2,000-meter level.

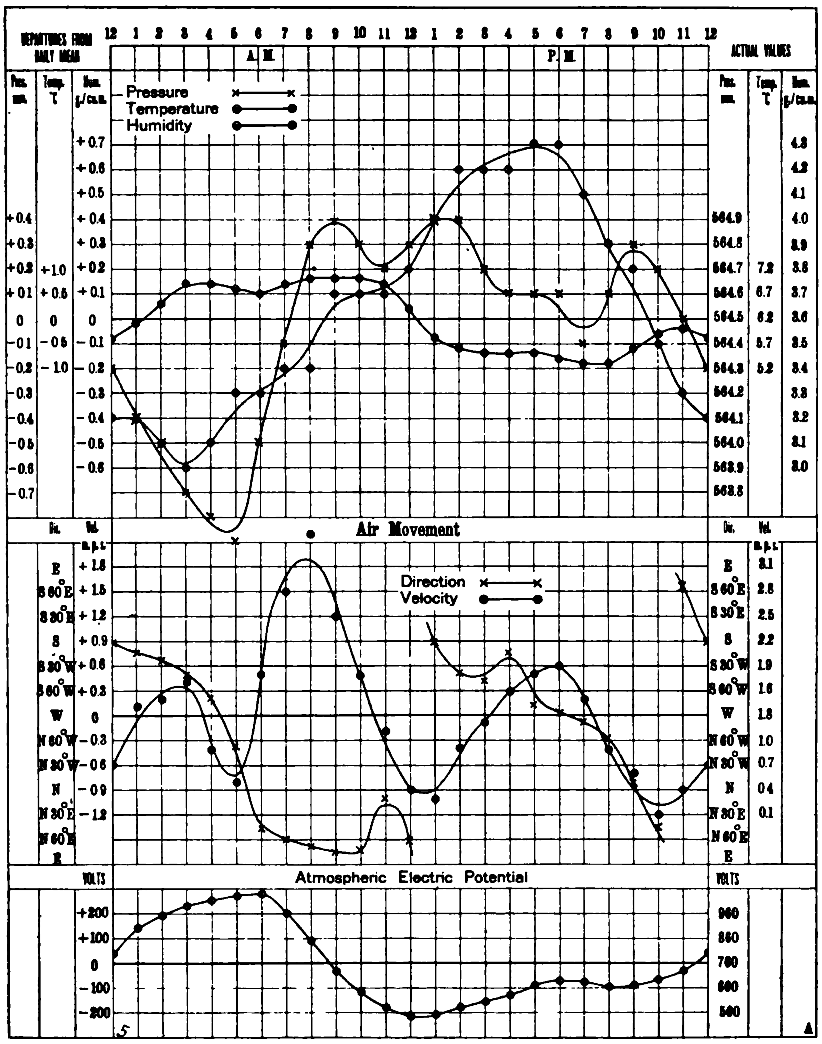

FIG. 5.— April to September mean curves of the diurnal variation at the 2,500-meter level.

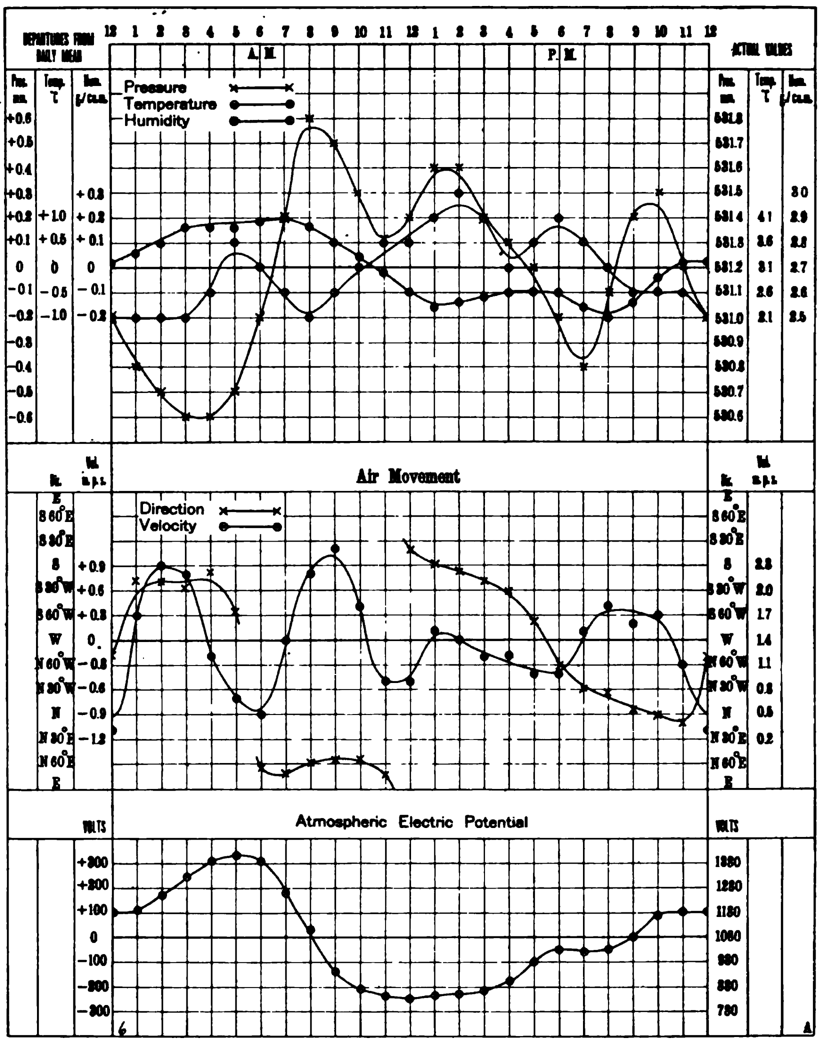

FIG. 6.—April to September mean curves of the diurnal variation at the 3,000-meter level.

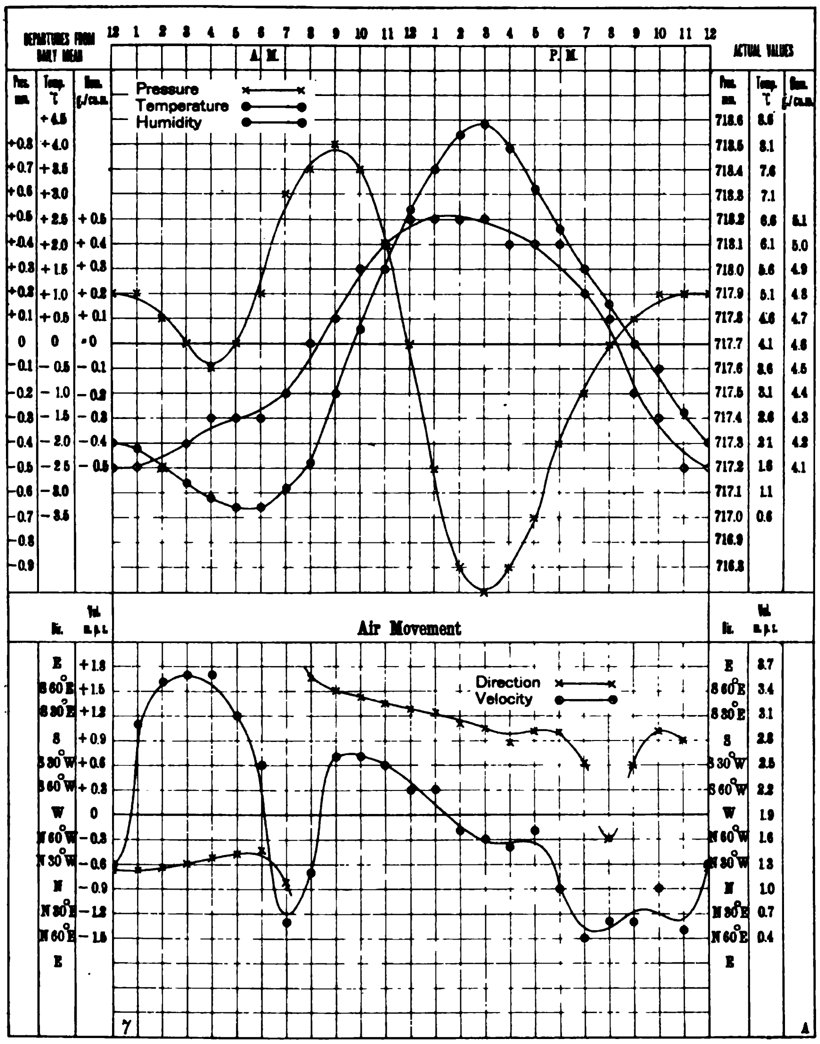

FIG. 7.—October to March mean curves of the diurnal variation at the 526-meter level.

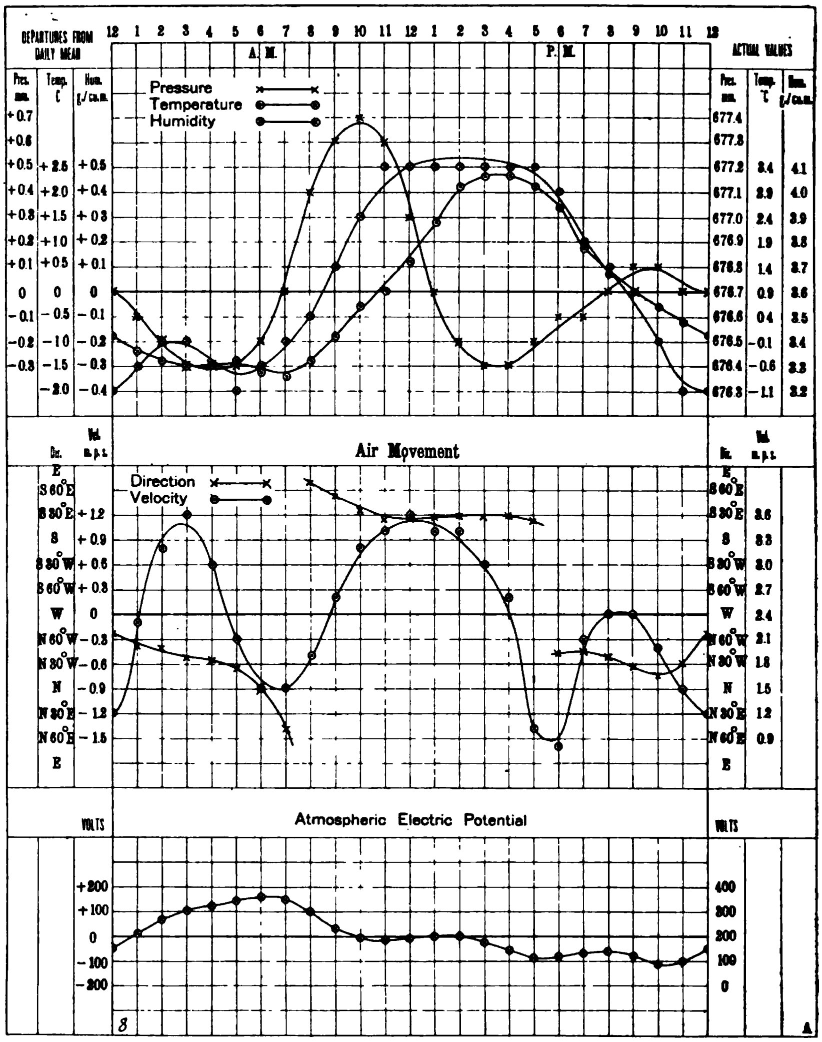

FIG. 8.—October to March mean curves of the diurnal variation at the 1,000-meter level.

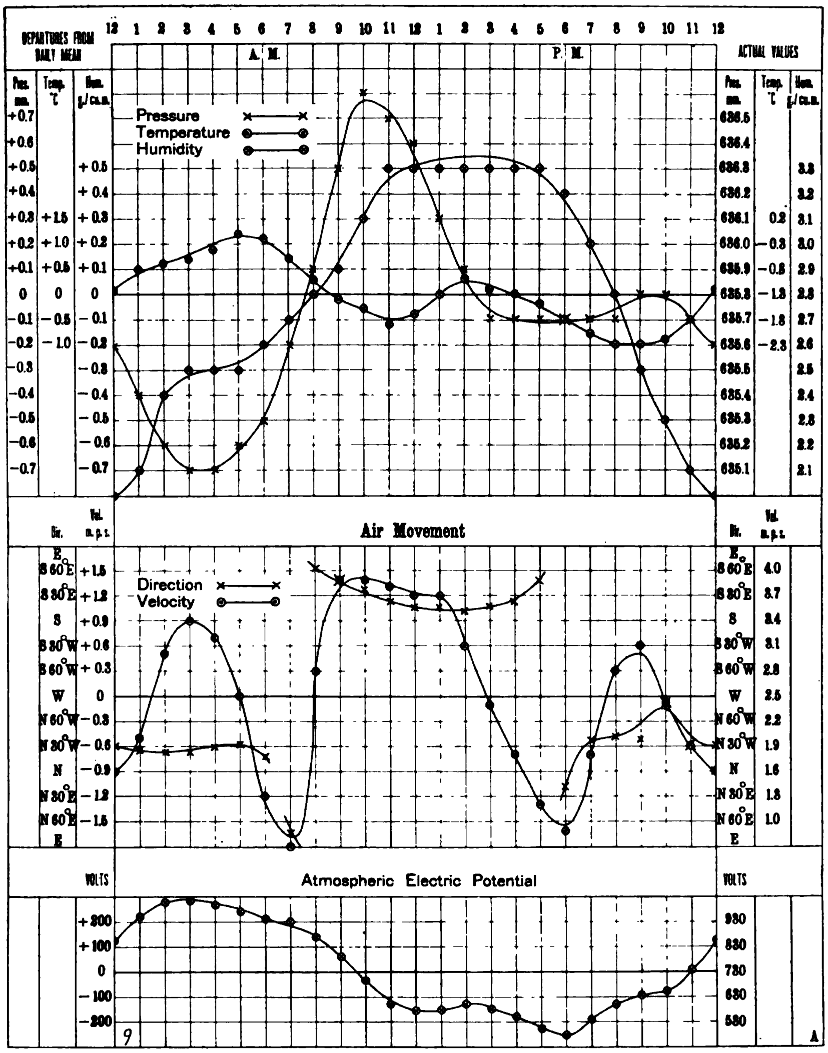

FIG. 9.—October to March mean curves of the diurnal variation at the 1,500-meter level.

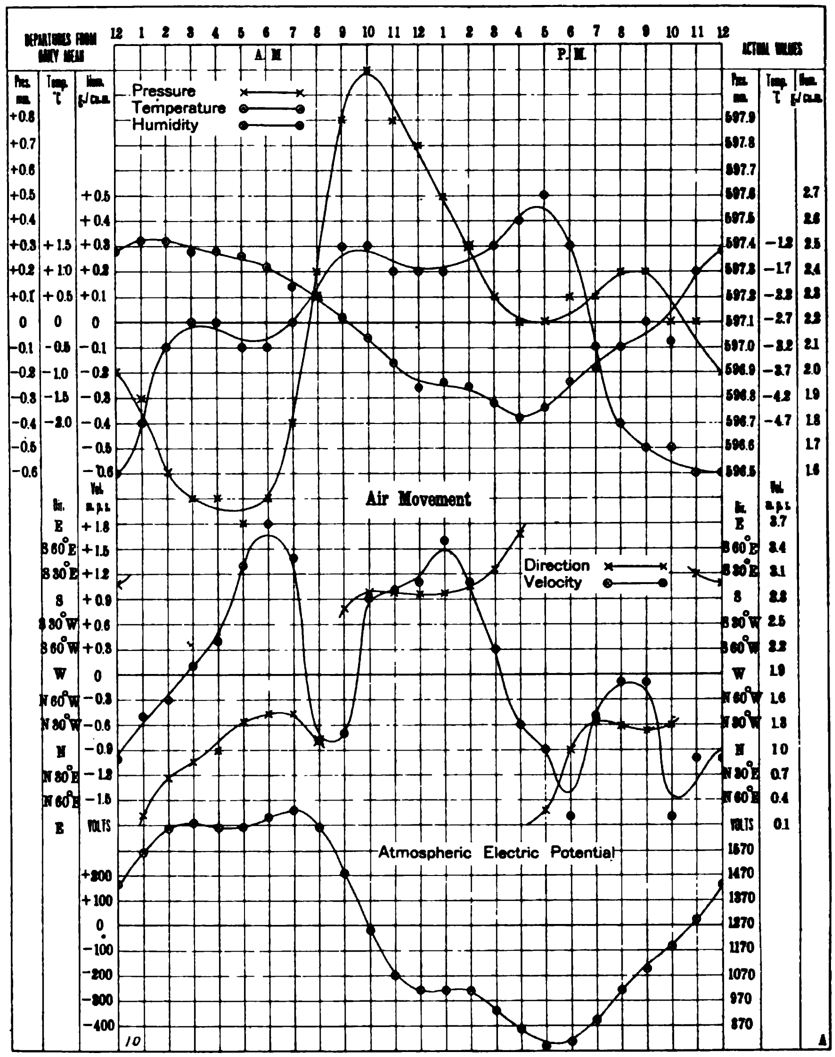

FIG. 10.—October to March mean curves of the diurnal variation at the 2,000-meter level.

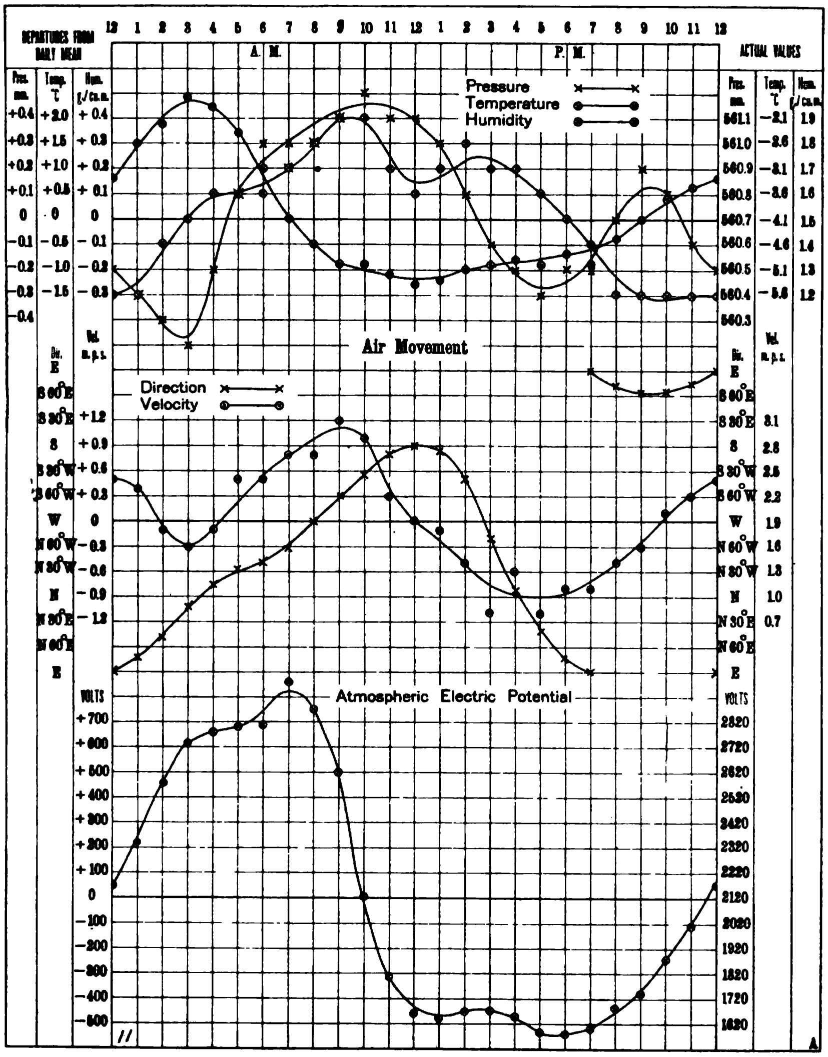

FIG. 11.--October to March mean curves of the diurnal variation at the 2,500-meter level.

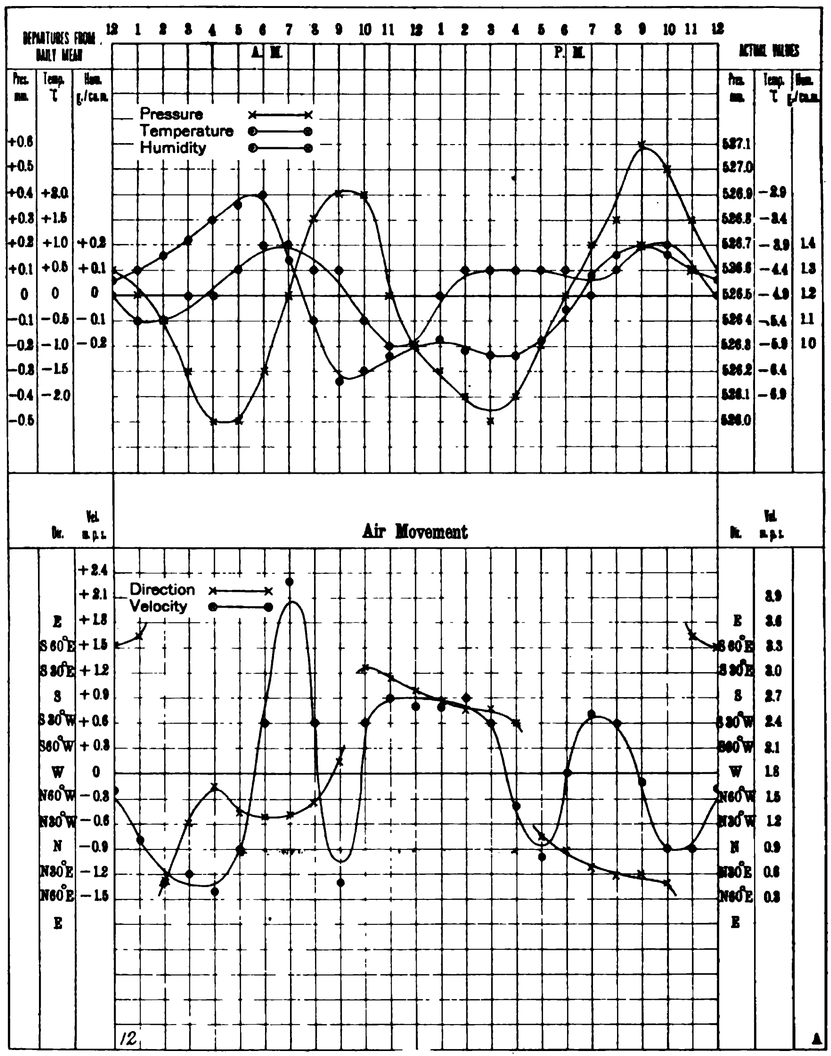

FIG. 12.--October to March mean curves of the diurnal variation at the 3,000-meter level.

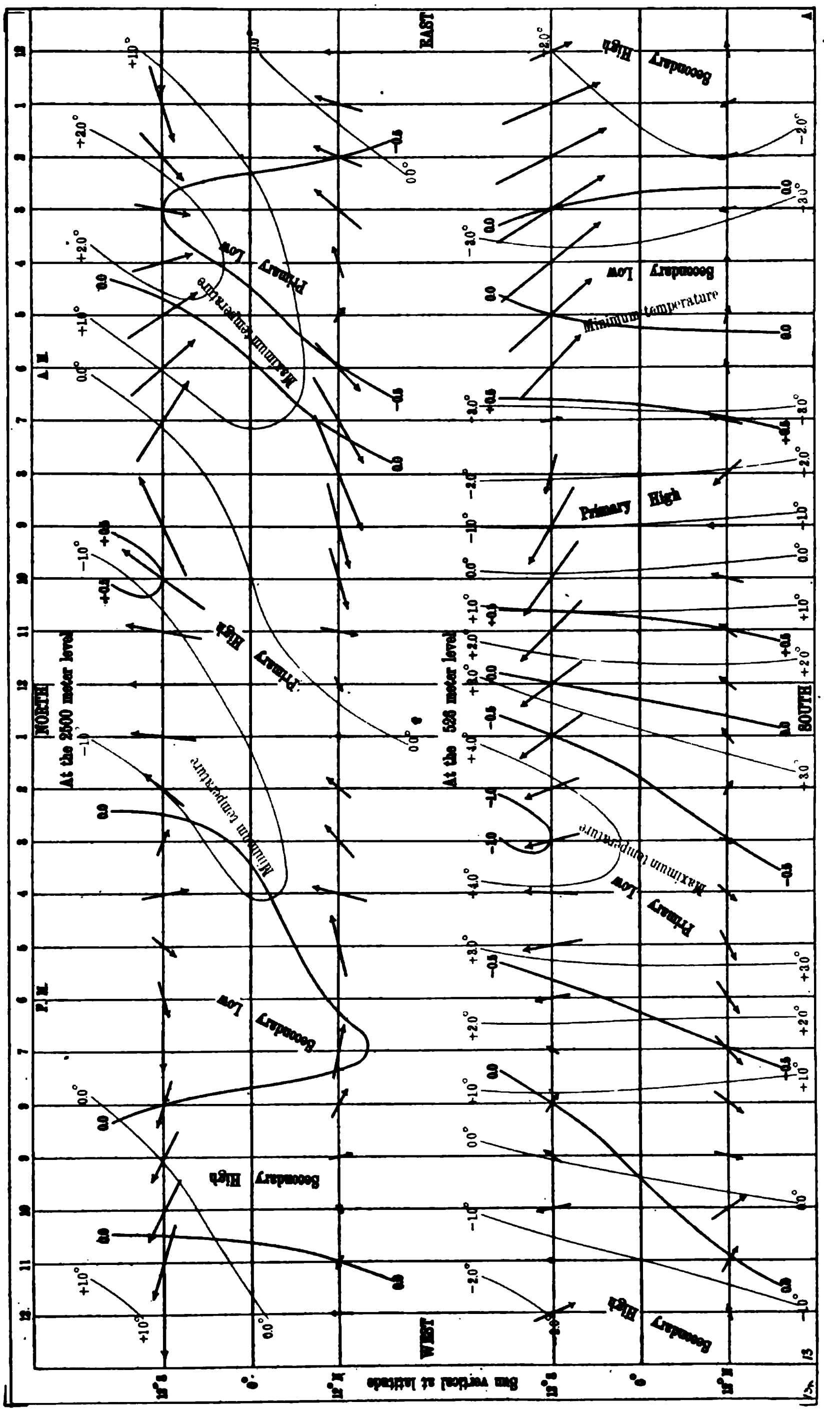

FIG. 13.—Comparison of the 526- and 2,500-meter levels of the diurnal variation in air pressure, temperature, and movement of the warmer and colder halves of the year.

13. FREE AIR DATA AT MOUNT WEATHER FROM JULY 3, 1913, TO MAY 7, 1914, ON "INTERNATIONAL DAYS."

By the Aerial Section, Wm. R. Blair, in Charge.

[Dated Mount Weather, Va., May 26, 1914.]

In the following tables the meteorograph records are interpreted in such detail that any record can be essentially reproduced from the tabulated data. Notes of the weather conditions at the time of observation accompany the data obtained in each observation. The method of observation is also noted.

Free-air observations on "international days" will be interrupted during the summer of 1914 pending the removal of the upper air work from Mount Weather, Va., and its reestablishment in the Middle West.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
July 3, 1913:	*mm.*	*C.*	*%*		*m. p. s*	*m.*	*mm.*	*C.*	*%*	*g/cu. m.*		*m. p. s*	*Volts.*
1.44 p. m.	721.0	26.4	65	e.	6.3	526	721.0	26.4	65	16.0	e.	6.3	......
2.04 p. m.	720.9	26.8	65	e.	7.2	773	700.9	22.8	70	14.1	se.	3.5	......
2.14 p. m.	720.8	26.6	65	e.	5.8	526	720.8	26.6	65	16.2	e.	5.8	......
July 10, 1913:													
10.26 a. m.	714.4	22.2	76	nw.	10.3	526	714.4	22.2	76	14.8	nw.	10.3	......
10.40 a. m.	714.5	22.2	76	nw.	9.4	868	686.8	17.4	84	12.3	nw.	13.1	0
10.57 a. m.	714.7	22.0	74	nw.	7.2	1,269	655.2	12.5	97	10.6	nw.	9.2	0
11.11 a. m.	714.7	22.7	69	nw.	9.8	1,817	613.8	9.6	60	5.5	wnw.	18.5	0
11.13 a. m.	714.7	22.8	68	nw.	9.8	1,831	612.7	8.9	60	5.2	wnw.	18.5	0
11.19 a. m.	714.7	22.7	67	nw.	8.9	1,899	607.6	11.7	38	3.9	wnw.	16.9	80
11.25 a. m.	714.7	22.7	66	nw.	9.4	2,357	575.3	9.6	28	2.5	wnw.	15.5	265
11.29 a. m.	714.7	22.8	65	nw.	9.4	2,400	572.3	10.3	24	2.3	wnw.	13.4	270
11.38 a. m.	714.8	22.7	64	nw.	10.7	2,658	555.0	9.4	18	1.6	wnw.	14.8	315
12.00 m.	714.8	22.9	62	nw.	10.7	3,314	512.2	−0.7	11	0.5	wnw.	17.7	425
12.22 p. m.	714.8	23.2	57	nw.	8.9	3,298	513.1	−0.1	9	0.4	wnw.	15.6	425
12.27 p. m.	714.8	23.2	57	nw.	9.4	3,314	512.2	0.0	9	0.4	wnw.	15.6	425
12.30 p. m.	714.8	23.2	57	nw.	8.0	3,321	511.4	0.3	8	0.4	wnw.	15.6	425
12.47 p. m.	714.9	23.3	57	nw.	8.5	3,011	531.3	2.8	7	0.4	w.	....	425
1.01 p. m.	714.9	23.2	58	nw.	7.2	2,514	564.5	8.0	7	0.6	wnw.	....	260
1.02 p. m.	714.9	23.3	59	nw.	7.2	2,459	568.3	8.0	7	0.6	wnw.	....	240
1.04 p. m.	714.9	23.4	60	nw.	6.3	2,344	576.3	8.5	7	0.6	wnw.	....	190
1.12 p. m.	714.9	23.5	58	nw.	8.0	2,217	585.2	8.8	7	0.6	w.	....	145
1.14 p. m.	714.9	23.4	57	nw.	8.5	2,057	596.4	7.5	13	1.0	w.	....	100
1.19 p. m.	714.9	23.4	56	wnw.	8.0	1,626	628.4	9.5	46	4.2	wnw.	12.6	0
1.34 p. m.	714.8	23.8	59	wnw.	8.0	1,233	658.5	13.5	71	8.2	wnw.	11.1	0
1.45 p. m.	714.8	23.5	56	wnw.	10.3	817	691.3	18.5	63	9.9	nw.	12.6	0
1.50 p. m.	714.8	23.4	57	wnw.	9.8	526	714.8	23.4	57	11.9	wnw.	9.8	......

July 3, 1913.—One kite was used; lifting surface, 8.3 sq. m. Wire out 500 m., at maximum altitude.

There were 3/10 St.-Cu. from the east-southeast.

A ridge of high pressure with centers (768 mm.) and (766 mm.) over northern New York and central Alabama, respectively, extended from Quebec to the Gulf of Mexico. Pressure was low (753 mm.) over Manitoba.

July 10, 1913.—Six kites were used; lifting surface, 37.8 sq. m. Wire out, 6,000 m.; at maximum altitude, 5,250 m.

5/10 St.-Cu., from the northwest, decreased to 3/10 and changed in direction to west-northwest before 11.30 a. m. Thereafter there were from 7/10 to 8/10 Ci.-St. and St.-Cu. from the west-northwest. The head kite emerged from the St.-Cu., altitude 1,200 m., at 10.58 a. m. Time of entering unknown.

At 8 a. m. high pressure (768 mm.) was central over Lake Superior. Low pressure (753 mm.) was central over the middle St. Lawrence Valley.

Results of free air observations—Continued.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Aug. 6, 1913:	*mm.*	*C.*	*%*		*m. p. s.*	*m.*	*mm.*	*C.*	*%*	*g/cu.m.*		*m. p. s.*	*Volts.*
First flight—													
8.25 a. m...	718.4	18.3	99	se.	5.8	526	718.4	18.3	99	15.3	se.	5.8	......
8.28 a. m...	718.4	18.4	98	se.	5.8	620	710.6	17.5	.....	....	sse.	12.5	0
8.29 a. m...	718.4	18.4	98	se.	5.8	701	703.9	17.8	.....	....	sse.	12.5	0
8.30 a. m...	718.4	18.4	98	se.	7.2	769	698.4	17.7	.....	....	sse.	12.5	0
8.32 a. m...	718.4	18.5	97	se.	7.2	865	690.6	18.5	.....	....	sse.	13.8	0
8.33 a. m...	718.4	18.6	96	se.	7.2	920	686.2	18.0	.....	....	sse.	12.6	0
8.41 a. m...	718.4	19.0	95	se.	6.7	1,056	675.3	17.8	.....	....	sse.	12.4	0
8.52 a. m...	718.4	19.4	95	se.	6.3	1,169	666.6	18.0	69	10.5	sse.	7.9	0
9.41 a. m...	718.5	19.8	91	sse.	8.0	1,408	648.3	16.1	72	9.8	sse.	7.3	0
10.02 a. m..	718.5	20.6	89	sse.	7.6	949	684.0	20.7	61	10.9	sse.	5.5	0
10.12 a. m..	718.4	21.4	83	sse.	7.2	1,947	608.4	12.7	75	8.3	ssw.	5.0	0
10.36 a. m..	718.3	21.6	81	se.	9.4	1,632	631.3	14.7	74	9.2	ssw.	5.2	0
10.51 a. m..	718.2	22.0	79	se.	8.9	1,322	654.7	17.4	65	9.5	ssw.	11.8	0
10.56 a. m..	718.1	22.1	76	se.	8.9	1,193	664.5	17.0	68	9.7	ssw.	12.2	0
10.58 a. m..	718.1	22.1	75	sse.	8.9	1,027	677.5	16.3	79	10.9	sse.	12.2	0
11.02 a. m..	718.1	22.1	75	sse.	9.4	933	685.1	16.9	86	12.3	sse.	10.5	0
11.08 a. m..	718.0	21.8	79	sse.	8.9	904	687.3	16.7	89	12.5	sse.	11.6	0
11.15 a. m..	718.0	22.0	78	sse.	9.8	526	718.0	22.0	78	15.0	sse.	9.8	......
Second flight—													
1.20 p. m..	717.2	24.7	62	sse.	9.4	526	717.2	24.7	62	13.9	sse.	9.4	......
1.37 p. m..	717.1	25.3	62	sse.	8.5	828	692.9	20.9	74	13.3	se.	9.7	0
1.47 p. m..	717.0	25.0	63	sse.	8.5	1,257	659.0	16.3	82	11.3	sse.	13.0	0
2.02 p. m..	716.9	25.4	61	se.	8.0	1,680	626.9	14.2	82	9.9	sse.	10.1	50
2.49 p. m..	716.6	25.2	62	sse.	8.9	2,148	592.9	8.9	76	6.6	sse.	7.6	150
3.32 p. m..	716.5	24.1	69	s.	8.0	2,353	578.0	5.3	86	5.9	ssw.	8.0	330
3.36 p. m..	716.5	24.1	68	s.	7.2	2,393	575.0	5.3	84	5.8	ssw.	8.0	330
3.40 p. m..	716.5	24.1	68	s.	8.0	2,467	570.0	5.5	82	5.7	ssw.	8.0	330
3.48 p. m..	716.5	23.9	68	s.	6.3	3,019	532.3	0.7	42	2.1	ssw.	11.3	......
4.04 p. m..	716.5	23.6	69	s.	6.3	2,612	559.5	3.5	74	4.5	ssw.	10.9	170
4.17 p. m..	716.4	23.4	69	s.	5.4	2,248	584.9	5.6	87	6.1	s.	11.1	170
4.30 p .m..	716.4	23.2	71	s.	6.3	1,826	615.4	10.5	79	7.6	s.	13.4	10
4.41 p. m..	716.3	23.1	70	s.	4.5	1,372	649.3	14.8	76	9.5	s.	15.1	0
5.02 p. m..	716.2	22.8	71	s.	7.6	884	687.3	19.0	70	11.3	s.	12.1	0
5.10 p. m..	716.2	22.5	74	s.	7.2	526	716.2	22.5	74	14.6	s.	7.2	......
Aug. 7, 1913:													
First flight—													
8.51 a. m...	716.5	16.9	100	nw.	5.8	526	716.5	16.9	100	14.3	nw.	5.8	......
9.02 a. m...	716.6	17.2	97	nw.	5.8	552	714.5	15.9	99	13.3	......	....	......
9.58 a. m...	716.7	17.4	99	nw.	6.7	742	699.0	19.2	88	14.4	......	....	......
10.04 a. m..	716.7	17.5	98	nw.	5.8	851	690.1	18.6	88	13.9	......	....	......
10.14 a. m..	716.7	17.6	98	nw.	5.8	810	693.4	18.9	87	14.0	......	....	......
10.17 a. m..	716.8	17.5	100	nw.	4.9	701	702.3	16.2	87	11.9	......	....	......
10.18 a. m..	716.8	17.5	100	nw.	4.9	526	716.8	17.5	100	14.8	nw.	4.9	......

August 6, 1913.—First flight: Five kites were used; lifting surface, 35.5 sq. m. Wire out, 4,000 m.; at maximum altitude, 3,300 m.

There was dense and light fog before 10.18 a. m. Thereafter, there were from 9/10 to 10/10 St.-Cu. from the south-southeast.

At 8 a. m. pressure was high (769 mm.) over the Bermudas. Low pressure (759 mm.) was central over northern Missouri.

Second flight: Six kites were used; lifting surface, 46.7 sq. m. Wire out, 5,500 m.; at maximum altitude, 4,800 m.

There were 10/10 St.-Cu. from the south-southeast. The head kite was in St.-Cu. altitude 1,800 m. at 2.14 p. m. and emerged at 2.15 p. m. It entered again at 2.19 p. m., but time of emerging unknown. Rain began at 4.56 p. m.

August 7, 1913.—First flight: Two kites were used; lifting surface, 19.5 sq. m. Wire out, 950 m.; at maximum altitude, 750 m.

There was dense fog.

At 8 a. m. low pressure (760 mm.) was central off the New Jersey coast. High pressure (765 mm.) covered Quebec and Ontario.

Results of free air observations—Continued.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Aug. 7, 1913:													
Second flight—	*mm.*	*C.*	%		*m. p. s.*	*m.*	*mm.*	*C.*	%	*g/cu.m.*		*m. p. s.*	*Volts.*
6.54 p. m...	716.8	22.5	71	se.	6.7	526	716.8	22.5	71	14.0	se.	6.7	......
7.06 p. m...	716.9	22.3	70	ese.	8.5	909	686.0	19.4	78	12.9	ese.	10.4	......
7.21 p. m...	717.0	22.1	70	ese.	6.3	1,101	670.8	16.6	81	11.3	ese.	8.0	80
8.03 p. m...	717.4	20.8	82	ese.	6.3	1,052	675.1	18.8	70	11.2	......	5.9	0
9.30 p. m...	717.9	20.3	86	se.	6.7	1,250	659.9	15.1	74	9.5	......	7.5	170
9.41 p. m...	717.9	20.0	89	se.	8.5	2,006	603.0	8.8	68	5.9	......	4.4	......
10.13 p. m..	718.0	19.6	92	se.	6.3	1,585	634.2	13.6	52	6.1	......	6.6	0
10.27 p. m..	718.1	19.7	93	sse.	6.7	1,180	665.3	15.7	61	8.1	......	8.0	0
10.50 p. m..	718.2	19.6	94	se.	4.9	906	687.1	16.4	73	10.1	......	8.3	0
10.58 p. m..	718.2	19.7	93	se.	4.9	526	718.2	19.7	93	15.6	se.	4.9	......
Aug. 8, 1913:													
11.22 a. m..	720.0	23.7	63	sse.	10.3	526	720.0	23.7	63	13.3	sse.	10.3	......
11.36 a. m..	719.9	24.4	64	sse.	8.9	839	694.5	18.6	.....	....	se.	10.0	0
11.55 a. m..	719.9	23.4	69	sse.	8.9	1,253	661.6	14.2	.....	....	se.	8.1	0
1.13 p. m..	719.9	24.8	59	se.	5.8	1,588	635.8	11.2	.....	....	s.	6.7	0
2.28 p. m..	719.6	24.8	58	se.	9.4	1,800	620.0	11.2	.....	....	s.	6.3	0
2.56 p. m..	719.4	24.5	56	s.	8.5	1,500	642.3	14.0	.....	....	s.	6.6	0
3.23 p. m..	719.2	24.6	58	sse.	5.8	943	685.6	18.6	.....	....	sse.	9.2	0
3.38 p. m..	719.1	24.3	62	sse.	8.9	526	719.1	24.3	62	13.6	sse.	8.9	......
Oct. 2, 1913:													
8.35 a. m...	706.2	15.6	76	wnw.	16.1	526	706.2	15.6	76	10.0	wnw.	16.1	......
8.50 a. m...	706.0	15.8	76	wnw.	14.3	955	671.1	12.5	76	8.3	wnw.	16.8	0
9.03 a. m...	705.9	16.3	74	wnw.	14.3	1,440	633.2	9.4	68	6.1	wnw.	16.8	0
9.24 a. m...	705.8	15.6	77	wnw.	15.2	1,999	591.6	4.9	60	4.0	wnw.	15.1	0
9.38 a. m...	705.8	16.5	74	wnw.	13.4	2,673	544.5	0.7	34	1.7	wnw.	16.0	0
9.41 a. m...	705.8	16.6	74	wnw.	14.3	2,711	541.8	0.7	32	1.6	wnw.	13.4	0
10.00 a. m..	705.7	17.0	72	wnw.	11.6	3,020	521.2	− 3.2	31	1.2	wnw.	10.1	30
10.32 a. m..	705.1	16.9	72	wnw.	14.3	3,473	491.4	−10.9	38	0.8	wnw.	18.5	380
11.34 a. m..	704.0	19.2	64	w.	12.5	3,730	474.4	−15.3	47	0.6	w.	19.3	620
12.16 p. m..	703.5	19.6	62	w.	11.6	4,102	449.2	−19.7	37	0.3	w.	....	......
1.20 p. m...	702.7	17.8	65	wsw.	11.2	3,341	494.0	−11.7	85	1.6	wsw.	....	......
1.35 p. m...	702.7	16.7	76	w.	8.5	2,521	549.2	− 6.3	97	2.8	w.	....	......
1.41 p. m...	702.7	15.1	87	w.	10.3	1,592	617.4	− 0.2	100	4.9	w.	....	......
1.53 p. m...	702.6	13.1	100	w.	8.0	1,456	628.0	3.2	98	5.9	w.	....	......
2.29 p. m...	702.5	12.4	100	w.	10.7	526	702.5	12.4	100	10.8	w.	10.7	......

August 7, 1913.—Second flight: Six kites were used; lifting surface, 48.2 sq. m. Wire out, 5,200 m.; at maximum altitude, 4,550 m.

St.-Cu. from the southeast decreased from 3/10 to a few.

August 8, 1913.—Five kites were used; lifting surface, 42.9 sq. m. Wire out, 4,100 m.; at maximum altitude, 3,600 m.

St.-Cu., which changed in direction from southeast to south, increased from 4/10 to 9/10. They also increased in altitude from 1,250 m., at 11.55 a. m., to 1,600 m., at 1.07 p. m. The head kite was in the clouds at 11.55 a. m. and again at 1.07 p. m.

At 8 a. m. pressure was high (769 mm.) off the Atlantic coast. Pressure was low over Saskatchewan (747 mm.) with secondary depressions over northern Kansas (754 mm.) and over the North Carolina coast (764 mm.).

October 2, 1913.—Eight kites were used; lifting surface, 50.4 sq. m. Wire out, 10,000 m.; at maximum altitude, 9,700 m.

There were from 2/10 to 6/10 A.-Cu. and a few St.-Cu. from the west-northwest before 10.10 a. m. After 10.10 a. m. the A.-Cu. decreased and the St.-Cu. increased, both kinds changing in direction, until at 11.50 a. m. there were a few A.-Cu. and 8/10 St.-Cu. from the west. Thereafter the A.-Cu. and the St.-Cu. gradually disappeared. A.-St., from the west-southwest; altitude, 4,000 m., appeared before 12.20 p. m., and increased to 6/10 by 12.50 p. m., when there were also 4/10 St.-Cu., altitude 1,850 m. After 1.50 p. m. there were 10/10 St. from the west. A few Ci. from the west were noted at 11.51 a. m. Rain began at 1.34 p. m. and continued during the remainder of the flight.

Results of free air observations—Continued.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Nov. 5, 1913:	*mm.*	*C.*	%		*m. p. s.*	*m.*	*mm.*	*C.*	%	*g/cu.m.*		*m. p. s.*	*Volts.*
8.21 a. m.	723.3	1.0	79	wnw.	13.4	526	723.3	1.0	79	4.1	wnw.	13.4	......
8.26 a. m.	723.4	1.2	76	wnw.	15.2	644	712.8	0.2	72	3.5	nw.	12.7	0
8.34 a. m.	723.4	1.2	76	wnw.	14.3	901	690.6	6.9	49	3.7	nnw.	9.3	0
9.04 a. m.	723.7	2.1	72	wnw.	11.6	843	696.1	9.8	36	3.3	n.	5.1	0
9.25 a. m.	723.8	2.7	70	wnw.	10.3	1,331	655.9	5.3	32	2.2	n.	......	0
9.35 a. m.	723.8	3.1	69	wnw.	9.8	816	698.4	8.1	32	2.6	n.	......	0
9.41 a. m.	723.8	3.4	65	wnw.	10.3	676	710.5	1.9	37	2.0	nnw.	7.6	0
9.44 a. m.	723.8	3.6	64	wnw.	8.9	526	723.8	3.6	64	3.9	wnw.	8.9	......
Nov. 6, 1913:													
1.55 p. m.	721.6	12.5	35	sse.	7.6	526	721.6	12.5	35	3.8	sse.	7.6	......
2.06 p. m.	721.6	12.9	28	sse.	6.7	698	706.9	8.9	31	2.7	sse.	7.1	0
2.29 p. m.	721.5	12.9	37	see.	7.2	882	691.4	11.4	22	2.2	ssw.	5.0	0
3.56 p. m.	721.4	12.2	39	see.	7.6	839	694.8	12.8	13	1.4	ssw.	......	0
4.18 p. m.	721.4	11.7	34	sse.	6.3	906	689.2	11.8	15	1.6	s.	3.6	0
4.29 p. m.	721.4	11.2	39	see.	7.6	813	697.0	9.4	18	1.6	sse.	6.4	0
4.32 p. m.	721.3	11.1	40	sse.	6.3	526	721.3	11.1	40	4.0	sse.	6.3	......
Nov. 7, 1913:													
10.19 a. m.	719.9	10.4	45	se.	6.3	526	719.9	10.4	45	4.3	se.	6.3	......
10.22 a. m.	719.9	10.4	45	se.	6.3	560	716.9	10.4	41	3.9	s.	9.6	0
10.29 a. m.	719.9	10.5	45	se.	6.3	771	699.2	12.2	34	3.6	s.	7.3	0
12.06 p. m.	718.8	11.4	47	se.	8.9	680	705.8	15.7	18	2.4	s.	5.0	0
12.51 p. m.	718.4	13.8	37	sse.	8.9	1,023	677.2	13.1	17	1.9	s.	2.3	0
1.12 p. m.	718.2	14.3	31	se.	8.9	832	691.4	9.7	20	1.8	s.	10.0	0
1.19 p. m.	718.2	14.8	31	se.	10.7	526	718.2	14.8	31	3.9	se.	10.7	......

October 2, 1913.—At 2 p. m. the kite wire was struck by lightning, that portion between the reel house and about 500 m. out being rendered incandescent by the intense heat. At the reel there was a blinding flash of light, and a loud report, accompanied by a shower of sparks and followed by an odor like that of burning powder. Wherever the "splice" wires were attached to the main wire, the latter was not injured; but the main portion, about 3,000 m., was entirely destroyed.

At 8 a. m., a well-developed low with depressions over Rhode Island (747 mm.) and over Lake Huron (748 mm.) extended from the Middle Atlantic coast to Hudson Bay. An extensive area of high pressure (766 mm.) was central over western Kansas,

November 5, 1913.—Three kites were used; lifting surface, 20.4 sq. m. Wire out, 1,900 m.; at maximum altitude, 1,450 m.

There were a few Ci. from the west.

At 8 a. m. high pressure (774 mm.), central over Ohio, dominated the weather conditions of the country except the northwest.

November 6, 1913.—Four kites were used; lifting surface, 28.7 sq. m. Wire out, 1,800 m.; at maximum altitude, 1,100 m.

There was a band of dense haze five degrees high around the horizon.

At 8 a. m. high pressure (772 mm.), central over Virginia, dominated weather conditions to the Mississippi.

November 7, 1913.—Five kites were used; lifting surface, 33.5 sq. m. Wire out, 3,200 m.; at maximum altitude, 1,650 m.

Ci. and Ci.-St. from the northwest decreased from 8/10 to 5/10. A solar halo was observed at 10.48 a. m.

At 8 a. m. low pressure (748 mm.) was central over southeastern Minnesota. High pressure (769 mm.) covered the Middle and North Atlantic coasts.

Results of free air observations—Continued.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Dec. 4, 1913:													
First flight—	*mm.*	*C.*	*%*		*m. p. s.*	*m.*	*mm.*	*C.*	*%*	*g/cu.m.*		*m. p. s.*	*Volts.*
8.18 a. m...	715.2	2.9	68	nw.	11.2	526	715.2	2.9	68	4.0	nw.	11.2	......
8.21 a. m...	715.2	3.0	68	nw.	11.6	603	708.5	2.9	48	2.8	nw.	....	0
8.22 a. m...	715.2	3.0	67	nw.	11.6	654	704.1	3.3	46	2.8	nw.	13.4	0
8.27 a. m...	715.1	3.1	66	nw.	11.6	886	684.1	2.6	44	2.5	nw.	15.9	0
8.28 a. m...	715.1	3.2	66	nw.	11.6	939	679.7	2.6	41	2.4	nw.	15.9	0
8.34 a. m...	715.1	3.2	66	nw.	13.4	963	677.6	3.2	34	2.0	nw.	17.7	0
8.38 a. m...	715.0	3.1	66	nw.	11.6	1,188	659.1	5.3	26	1.8	nnw.	....	100
8.41 a. m...	715.0	3.0	66	nw.	11.6	1,310	649.3	5.2	21	1.4	nnw.	....	160
8.43 a. m...	715.0	2.9	67	nw.	11.2	1,350	646.2	6.5	16	1.2	nnw.	....	170
9.00 a. m..	714.9	2.8	69	nw.	11.6	1,817	610.3	4.5	10	0.7	nnw.	....	530
9.06 a. m...	714.9	3.2	68	nw.	9.4	2,051	592.9	3.4	16	1.0	nnw.	....	640
9.12 a. m...	714.8	3.4	67	nw.	9.8	2,273	576.9	4.9	8	0.5	nnw.	....	750
9.42 a. m...	714.6	4.2	62	nw.	12.1	2,535	558.4	3.1	13	0.8	nnw.	....	......
10.11 a. m..	714.4	4.3	62	nw.	13.4	2,159	584.8	3.9	14	0.9	nnw.	....	550
10.25 a. m..	714.4	4.3	61	nw.	15.2	1,963	599.0	3.7	5	0.3	nnw.	....	460
11.49 a. m..	713.6	7.4	47	nw.	15.6	526	713.6	7.4	47	3.6	nw.	15.6	......
Second flight—													
1.26 p. m...	712.6	9.4	35	nw.	21.5	526	712.6	9.4	35	3.1	nw.	21.5	......
1.37 p. m...	712.5	9.6	35	nw.	20.6	815	688.2	6.6	39	2.9	nw.	16.4	......
1.43 p. m...	712.4	9.8	37	nw.	20.6	1,149	660.4	4.4	42	2.7	nw.	21.0	......
1.47 p. m...	712.4	10.0	39	nw.	14.8	1,322	646.7	6.2	39	2.9	nw.	21.8	......
1.48 p. m...	712.4	10.0	39	nw.	14.8	1,363	643.4	4.8	38	2.5	nw.	21.8	......
1.52 p. m...	712.4	10.1	40	nw.	17.4	1,375	642.4	7.5	28	2.2	nw.	18.5	......
1.59 p. m...	712.3	10.2	41	nw.	17.4	1,514	631.7	8.1	20	1.7	nw.	18.9	......
2.02 p. m...	712.3	10.3	41	nw.	17.4	1,765	612.8	7.4	17	1.3	nw.	19.3	......
2.04 p. m...	712.3	10.3	42	nw.	18.8	1,918	601.4	7.6	16	1.3	nw.	20.1	......
2.13 p. m...	712.2	10.1	40	nw.	17.4	2,058	591.2	6.1	16	1.2	nnw.	19.7	......
2.26 p. m...	712.2	10.1	40	nw.	18.8	2,729	545.1	0.3	32	1.6	nnw.	21.6	......
2.29 p. m...	712.2	10.1	40	nw.	17.4	2,840	536.9	0.0	34	1.6	nnw.	19.9	......
2.36 p. m...	712.1	10.1	41	nw.	18.8	3,066	521.8	− 3.8	40	1.4	nnw.	21.8	......
2.38 p. m...	712.1	10.0	44	nw.	13.9	3,116	518.5	− 3.4	40	1.5	nnw.	22.7	......
3.17 p. m...	712.0	9.8	49	nw.	13.9	3,977	463.5	−14.7	46	0.7	nnw.	31.1	......
3.50 p. m...	711.9	9.5	50	nw.	14.3	3,663	482.9	−11.7	49	0.9	nnw.	....	......
4.01 p. m...	711.9	9.3	51	nw.	14.3	3,422	498.0	− 8.6	41	1.0	nnw.	....	......
4.03 p. m...	711.9	9.3	51	nw.	14.3	3,382	500.5	− 8.5	40	1.0	nnw.	....	......
4.15 p. m...	711.8	9.2	51	nw.	12.1	3,254	508.9	− 6.3	40	1.2	nnw.	....	......
4.40 p. m...	711.6	9.0	53	nw.	15.6	2,733	543.4	− 1.3	40	1.7	nnw.	....	......
5.00 p. m...	711.5	8.7	52	nw.	16.1	2,094	588.1	5.3	42	2.9	nw.	18.5	......
5.05 p. m...	711.5	8.7	52	nw.	16.1	2,021	593.2	6.7	41	3.1	nw.	16.3	......
5.08 p. m...	711.5	8.6	53	nw.	16.1	1,923	600.3	6.3	40	2.9	nw.	17.2	......
5.17 p. m...	711.6	8.6	53	nw.	16.1	1,616	623.2	8.0	40	3.3	nw.	15.5	......
5.18 p. m...	711.6	8.6	53	nw.	15.6	1,544	628.6	7.5	36	2.9	nw.	....	......
5.22 p. m...	711.6	8.5	54	nw.	16.1	1,352	643.4	7.2	29	2.3	nw.	....	......
5.25 p. m...	711.6	8.5	54	nw.	15.2	1,199	655.4	4.8	26	1.7	nw.	....	......
5.32 p. m...	711.6	8.5	54	nw.	14.8	1,131	660.8	4.2	36	2.3	nw.	19.1	......
5.40 p. m...	711.6	8.7	53	nw.	13.4	869	682.6	5.6	48	3.4	nw.	15.1	......
5.50 p. m...	711.7	8.2	56	nw.	17.0	526	711.7	8.2	56	4.7	nw.	17.0	......

December 4, 1913.—First flight: Five kites were used; lifting surface, 32.0 sq. m. Wire out, 4,950 m.; at maximum altitude, 4,350 m.

Ci., A.-Cu., and A.-St. from the north-northwest varied from a few to 9/10.

At 8 a. m. high pressure (773 mm.) was central over Wyoming. Pressure was low (744 mm.) over Newfoundland.

Second flight: Five kites were used; lifting surface, 28.5 sq. m. Wire out, 8,000 m.; at maximum altitude.

Ci., A.-Cu., and A.-St. from the north-northwest varied from 1/10 to 9/10. A lunar corona was observed at 5.50 p. m.

At 8 a. m. high pressure (773 mm.) was central over Wyoming. Pressure was low (744 mm.) over Newfoundland.

Results of free air observations—Continued.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		D. P. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Jan. 9, 1914:	*mm.*	*C.*	%		*m. p. s.*	*m.*	*mm.*	*C.*	%	*g/cu.m.*		*m. p. s.*	*Volts.*
12.56 p. m..	698.4	8.4	57	wsw.	10.3	526	698.4	8.4	57	4.8	wsw.	10.3	......
1.02 p. m..	698.4	8.0	61	wsw.	10.3	961	....	7.2	58	4.5	wsw.	11.3	......
1.24 p. m..	698.4	8.2	56	wsw.	7.6	1,375	....	3.8	72	4.5	wsw.	7.4	......
1.46 p. m..	698.5	8.3	58	wsw.	7.2	2,209	....	−3.0	100	3.8	w.	18.5	......
2.04 p. m..	698.5	8.0	63	wsw.	6.3	2,571	....	−6.1	99	2.9	w.	....	......
2.16 p. m..	698.5	8.2	64	wsw.	7.2	2,860	....	−7.5	97	2.6	w.	....	......
2.50 p. m..	698.6	8.3	60	wsw.	6.7	2,106	....	−2.4	98	3.9	w.	....	......
3.15 p. m..	698.6	8.8	60	wsw.	5.8	1,800	....	−1.3	99	4.3	w.	....	......
3.28 p. m..	698.6	8.8	60	sw.	5.4	1,337	....	0.2	88	4.3	wsw.	....	......
3.43 p. m..	698.6	8.8	60	sw.	5.4	974	....	4.4	76	4.9	sw.	....	......
3.52 p. m..	698.6	8.3	64	sw.	4.5	526	698.6	8.3	64	5.4	sw.	4.5	......
Feb. 2, 1914:													
2.47 p. m...	724.9	4.6	39	se.	8.0	526	724.9	4.6	39	2.6	se.	8.0	......
3.08 p. m...	724.7	4.8	40	se.	8.0	776	....	3.4	40	2.4	se.	7.7	0
3.31 p. m...	724.6	5.2	43	se.	9.4	1,442	....	−1.0	47	2.1	sse.	11.1	0
3.32 p. m...	724.6	5.2	43	se.	8.9	1,486	....	0.1	45	2.2	sse.	13.0	60
3.34 p. m...	724.6	5.2	43	se.	7.2	1,492	....	0.1	45	2.2	s.	13.0	70
3.36 p. m...	724.6	5.2	44	se.	7.2	1,601	....	0.6	39	2.0	s.	14.1	200
3.39 p. m...	724.5	5.3	45	se.	7.6	1,613	....	0.0	39	1.9	s.	12.8	205
3.46 p. m...	724.5	5.4	48	se.	8.9	1,916	....	2.3	28	1.6	sw.	13.4	400
3.52 p. m...	724.5	5.4	49	se.	8.0	2,206	....	2.3	28	1.6	sw.	13.0	510
3.53 p. m...	724.4	5.4	49	se.	8.0	2,237	....	2.0	28	1.6	sw.	13.0	515
3.56 p. m...	724.4	5.4	50	se.	9.8	2,279	....	1.8	28	1.5	sw.	13.5	540
4.14 p. m...	724.4	5.2	56	se.	9.8	2,905	....	−1.3	28	1.2	sw.	17.6	755
4.29 p. m...	724.4	5.2	56	se.	9.8	3,402	....	−3.0	25	1.0	wsw.	....	980
4.50 p. m...	724.3	4.4	41	se.	8.9	2,969	....	−2.0	24	1.0	wsw.	....	730
5.06 p. m...	724.3	3.9	42	se.	8.0	2,450	....	0.0	26	1.3	wsw.	15.5	380
5.18 p. m...	724.2	3.6	42	se.	8.0	1,979	....	1.1	23	1.2	sw.	....	280
5.23 p. m...	724.2	3.5	42	se.	8.9	1,631	....	−0.3	24	1.1	ssw.	11.3	220
5.25 p. m...	724.2	3.5	42	se.	8.0	1,548	....	−0.3	25	1.2	ssw.	16.0	170
5.27 p. m...	724.2	3.5	43	se.	8.5	1,506	....	0.2	26	1.3	ssw.	16.0	170
5.28 p. m...	724.2	3.4	43	se.	8.5	1,461	....	−0.4	27	1.3	ssw.	14.3	170
5.30 p. m...	724.2	3.4	44	se.	8.5	1,452	....	0.5	27	1.4	ssw.	14.3	170
5.34 p. m...	724.1	3.3	44	se.	8.5	1,235	....	0.2	31	1.5	sse.	13.5	100
5.46 p. m...	724.1	3.0	45	se.	8.5	891	....	1.9	41	2.3	se.	11.8	0
5.54 p. m...	724.0	2.8	44	se.	8.9	526	724.0	2.8	44	2.6	se.	8.9	......

January 9, 1914.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 5,000 m., at maximum altitude.

There were 10/10 St.-Cu. from the west. The head kite was at the base of the clouds, altitude 2,150 m., at 1.40 p. m. It entered the clouds about 1.46 p. m. and emerged at 2.42 p. m. It entered again at 3.15 and emerged at 3.17 p. m. The cloud level decreased in altitude from 2,200 m. at 1.46 to 1,650 m. at 3.03 p. m., but increased thereafter to 1,750 m. before 3.15 p. m.

At 8 a. m. low pressure (741 mm.) central over Lake St. Clair, dominated the weather conditions over the eastern half of the country.

February 2, 1914.—Five kites were used; lifting surface, 34 sq. m. Wire out, 4,200 m., at maximum altitude.

There were a few to 1/10 Ci. from the west.

At 8 a. m. an extensive area of high pressure, with centers over Pennsylvania (775 mm.) and over eastern Ontario (775 mm.), extended from the Carolinas to Hudson Bay. Low pressure with depressions over western Iowa (756 mm.) and over southern Kansas (758 mm.) extended from Texas to Minnesota.

Results of free air observations—Continued.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Feb. 3, 1914:	*mm.*	*C.*	%		*m. p. s.*	*m.*	*mm.*	*C.*	%	*g/cu.m.*		*m. p. s.*	*Volts.*
8.56 a. m.	722.3	8.0	47	wsw.	4.5	526	722.3	8.0	47	3.9	wsw.	4.5	......
9.13 a. m.	722.2	7.7	49	wsw.	3.6	977	....	7.3	48	3.8	wnw.	10.3	0
9.29 a. m.	722.2	7.0	55	wsw.	4.5	1,501	....	3.5	65	4.0	wnw.	11.3	490
10.06 a. m.	722.0	7.3	53	w.	7.2	2,111	....	1.0	57	3.0	sw.	11.3	805
10.07 a. m.	722.0	7.4	53	w.	7.2	2,206	....	1.1	57	3.0	sw.	11.3	875
11.24 a. m.	721.6	10.4	41	wsw.	3.6	2,858	....	− 3.7	86	3.1	wsw.	12.2	950
11.31 a. m.	721.5	10.6	39	wsw.	1.8	3,263	....	− 4.5	75	2.5	wsw.	16.9	......
11.37 a. m.	721.5	11.0	39	wsw.	1.8	3,426	....	− 4.2	66	2.3	wsw.	21.3	......
12.20 p. m.	721.1	11.0	42	w.	2.7	526	721.1	11.0	42	4.2	w.	2.7	......
Feb. 4, 1914:													
8.33 a. m.	715.4	6.2	81	nw.	9.4	526	715.4	6.2	81	5.9	nw.	9.4	......
8.48 a. m.	715.4	6.4	81	nw.	13.0	987	....	3.0	92	5.4	wnw.	16.6	260
9.08 a. m.	715.4	6.7	81	nw.	12.5	1,821	....	− 3.8	99	3.5	w.	17.6	640
9.11 a. m.	715.4	6.9	80	nw.	13.9	1,909	....	− 3.9	99	3.5	w.	20.9	660
9.19 a. m.	715.4	7.1	81	nw.	11.6	2,181	....	2.3	35	2.0	w.	18.4	790
9.38 a. m.	715.5	7.0	79	nw.	13.0	2,706	....	0.5	16	0.8	w.	17.0	860
10.04 a. m.	715.5	7.6	75	nw.	14.3	3,274	....	− 4.2	9	0.3	w.	15.3	950
10.27 a. m.	715.6	7.6	75	nw.	14.8	4,011	....	−12.2	6	0.1	w.	20.7	1,040
10.32 a. m.	715.6	7.5	75	nw.	13.0	4,128	....	−12.2	6	0.1	w.	20.2	1,040
10.34 a. m.	715.6	7.5	75	nw.	12.5	4,190	....	−12.7	5	0.1	w.	20.2	1,040
10.37 a. m.	715.6	7.4	74	nw.	13.0	4,286	....	−12.7	5	0.1	w.	21.0	1,040
10.44 a. m.	715.6	7.2	74	nw.	12.1	4,364	....	−14.0	5	0.1	wsw.	21.4	1,040
11.35 a. m.	715.6	7.2	66	nw.	15.6	5,196	....	−18.3	7	0.1	wsw.	....	1,470
11.41 a. m.	715.6	7.3	64	nw.	15.2	5,211	....	−18.1	8	0.1	wsw.	....	......
1.02 p. m.	715.7	7.5	60	nw.	13.4	4,151	....	−15.9	14	0.2	w.	20.8	1,190
1.09 p. m.	715.7	7.5	59	nw.	9.8	4,016	....	−15.7	12	0.2	w.	17.5	1,130
1.52 p. m.	715.6	7.6	58	nw.	11.2	2,504	....	− 5.0	8	0.3	wnw.	....	460
2.10 p. m.	715.6	7.9	53	nw.	11.2	1,998	....	− 1.6	8	0.3	wnw.	....	130
2.14 p. m.	715.5	8.0	52	nw.	10.7	1,725	....	− 1.7	7	0.3	wnw.	....	0
2.15 p. m.	715.5	8.0	52	nw.	10.7	1,669	....	− 2.2	7	0.3	wnw.	....	0
2.46 p. m.	715.4	8.4	52	nnw.	9.4	946	....	1.8	64	3.5	nw.	9.3	0
2.59 p. m.	715.3	8.6	51	nnw.	7.2	526	715.3	8.6	51	4.4	nnw.	7.2	......
Feb. 7, 1914:													
10.48 a. m.	702.0	2.6	91	wnw.	12.1	526	702.0	2.6	91	5.2	wnw.	12.1	......
11.04 a. m.	702.2	3.2	78	wnw.	13.4	1,007	....	0.0	77	3.7	wnw.	19.7	0
11.19 a. m.	702.2	2.8	81	wnw.	15.2	1,580	....	− 3.2	82	3.1	w.	20.4	0
11.35 a. m.	702.3	3.6	76	w.	15.2	2,413	....	− 9.4	43	1.0	w.	30.0	615
11.38 a. m.	702.3	3.9	71	w.	12.5	2,483	....	− 9.4	37	0.8	w.	29.7	......
11.41 a. m.	702.3	4.1	66	w.	17.4	2,571	....	− 7.6	34	0.9	w.	....	......
11.45 a. m.	702.3	4.5	59	w.	17.0	2,720	....	− 7.0	27	0.7	w.	....	......

February 3, 1914.—Five kites were used; lifting surface, 33.5 sq. m. Wire out, 4,600 m.; at maximum altitude, 3,650 m.

There were 10/10 A.-St., St.-Cu. and St. from the west-southwest.

At 8 a. m. pressure was low (759 mm.) north of Lake Huron. High pressure (775 mm.) was central over western North Dakota.

February 4, 1914.—Six kites were used; lifting surface, 34.8 sq. m. Wire out, 10,000 m.; at maximum altitude, 9,850 m.

7/10 St.-Cu., from the west, at the beginning of the flight decreased to a few; Ci., from the west, appearing about 10 a. m. increased to 6/10. The head kite was at the base of the St.-Cu., altitude 1,750 m. at 9.04 a. m. and in the clouds at intervals about 9.10 a. m.

At 8 a. m. low pressure (756 mm.) was central over southern Quebec. Pressure was high (775 mm.) over central Alberta and Saskatchewan with a secondary elevation (770 mm.) over eastern Iowa.

February 7, 1914.—Four kites were used; lifting surface, 21.3 sq. m. Wire out, 4,900 m., at maximum altitude.

There was 1/10 St.-Cu. from the west-southwest.

At 8 a. m. low pressure (739 mm.) was central over eastern Ontario. High pressure (773 mm.) was central over central Oklahoma.

Results of free air observations—Continued.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.							
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Mar. 4, 1914:													
First flight—	*mm.*	*C.*	*%*		*m. p. s.*	*m.*	*mm.*	*C.*	*%*	*g/cu.m.*		*m. p. s.*	*Volts.*
8.36 a. m...	711.8	−1.3	41	wnw.	11.6	526	711.8	− 1.3	41	1.8	wnw.	11.6	......
8.51 a. m...	711.9	−1.3	44	wnw.	10.7	1,026	668.4	− 4.0	40	1.4	wnw	....	0
8.56 a. m...	711.9	−1.3	44	wnw.	11.6	1,346	641.9	− 5.5	42	1.3	wnw	....	0
9.15 a. m...	711.9	−1.1	41	wnw.	10.7	989	671.7	− 2.9	42	1.6	nw.	....	0
9.21 a. m...	711.9	−1.0	40	wnw.	10.3	526	711.9	− 1.0	40	1.8	wnw.	10.3	......
Second flight—													
10.18 a. m..	712.0	0.4	42	wnw.	12.1	526	712.0	0.4	42	2.1	wnw.	12.1	......
10.32 a. m..	712.0	0.6	46	wnw.	12.1	999	671.0	− 2.7	47	1.8	wnw.	....	0
10.43 a. m..	712.0	1.0	40	wnw.	12.1	1,546	626.2	− 5.9	55	1.7	wnw.	....	390
10.44 a. m..	712.0	1.0	40	wnw.	12.1	1,576	624.1	− 3.2	57	2.1	wnw.	....	380
10.52 a. m..	712.0	1.0	40	wnw.	16.1	1,899	598.9	− 4.6	59	2.0	wnw.	....	720
10.54 a. m..	712.0	1.0	40	wnw.	16.1	2,261	572.2	− 2.1	53	2.2	wnw.	....	1,105
11.20 a. m..	711.9	1.0	49	wnw.	13.4	2,355	565.5	− 3.9	.....	....	wnw.	....	900
11.26 a. m..	711.9	1.0	49	wnw.	16.1	2,701	541.4	− 1.7	.....	....	w.	....	1,140
11.35 a. m..	711.8	1.1	47	wnw.	16.1	3,237	505.8	− 4.9	.....	....	w.	....	1,240
12.07 p. m..	711.7	1.5	49	wnw.	15.2	4,018	457.3	−12.1	.....	....	w.	....	......
Mar. 5, 1914:													
8.48 a. m..	715.6	−3.6	96	se.	7.2	526	715.6	−3.6	96	3.5	se.	7.2	......
8.56 a. m..	715.5	−3.8	99	se.	7.2	708	699.3	−4.1	84	2.9	sse.	11.6	0
9.22 a. m..	715.3	−3.1	93	se.	7.2	1,014	672.5	−2.2	65	2.6	s.	13.2	280
10.12 a. m..	714.8	−2.6	91	se.	9.4	1,419	638.7	−3.8	79	2.8	ssw.	12.6	690
10.19 a. m..	714.8	−2.6	91	se.	8.9	1,936	598.2	−2.3	92	3.7	sw.	14.5	1,040
11.44 a. m..	714.5	−2.8	96	se.	8.0	3,094	516.2	−7.9	89	2.3	wsw.	13.3	1,930
12.15 p. m..	714.3	−2.8	97	se.	9.4	3,471	491.3	−9.8	89	1.9	wsw.	22.2	......
12.47 p. m..	713.8	−3.0	98	se.	7.2	2,616	547.9	−6.4	91	2.6	wsw.	13.8	1,420
1.05 p. m..	713.6	−3.0	98	se.	7.2	2,147	581.6	−4.7	94	3.1	sw.	21.0	1,510
1.13 p. m..	713.5	−3.0	98	se.	7.6	1,654	618.9	−2.7	96	3.7	sw.	16.8	840
1.22 p. m..	713.5	−3.0	98	se.	8.5	1,438	636.0	−2.7	96	3.7	s.	....	600
1.28 p. m..	713.5	−3.0	98	se.	8.5	1,172	657.5	−1.0	100	4.5	se.	....	300
1.36 p. m..	713.4	−3.0	98	se.	7.6	894	680.8	−4.8	99	3.3	se.	....	0
1.47 p. m..	713.4	−3.0	98	se.	7.2	526	713.4	−3.0	98	3.7	se.	7.2	......

March 4, 1914.—First flight: Two kites were used; lifting surface, 12.6 sq. m. Wire out, 1,270 m., at maximum altitude.

There were 10/10 St.-Cu. from the west.

At 8 a. m. pressure was low (743 mm.) over the Grand Banks and relatively high (765 mm.) over Illinois.

Second flight: Five kites were used; lifting surface, 26.5 sq. m. Wire out, 6,500 m.; at maximum altitude, 6,350 m. St.-Cu., from the west, decreased from 4/10 to 2/10.

March 5, 1914.—Six kites were used; lifting surface, 37.8 sq. m. Wire out, 6,400 m.; at maximum altitude, 5,650 m.

There were 10/10 St. from the southwest until 12.15 p. m.; thereafter, dense fog. Light fog, from the southeast, at the beginning of the flight, coming and going at irregular intervals, became dense at 12.15 p. m. Light snow fell after 10.43 a. m. The head kite was in the clouds, altitude 1,900 m., at intervals about 10.17 a. m. It entered finally at 10.33 a. m. The kites and wire were heavily coated with frost.

At 8 a. m. an extensive area of low pressure, with centers over western Florida (755 mm.) and over eastern Minnesota (751 mm.), extended from the Gulf of Mexico to Canada. Pressure was high over eastern Ontario (765 mm.) and over New Jersey (765 mm.).

Results of free air observations—Continued.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.								
	Pressure.	Temperature.	Rel. hum.	Wind.		Height	Pressure.	Temperature.	Humidity.		Wind.		P. D. kite and earth.
				Dir.	Vel.				Rel.	Abs.	Dir.	Vel.	
Apr. 2, 1914:													
First flight—	*mm.*	*C.*	%		*m. p. s.*	*m.*	*mm.*	*C.*	%	*g/cu.m.*		*m. p. s.*	*Volts.*
8.26 a. m.	708.2	8.9	73	nw.	8.0	526	708.2	8.9	73	6.4	nw.	8.0	......
8.42 a. m.	708.2	8.8	69	wnw.	6.3	940	673.4	5.0	75	5.1	wnw.	17.2	......
8.56 a. m.	708.2	8.9	69	wnw.	5.8	1,787	606.0	− 3.2	97	3.6	w.	......	......
9.10 a. m.	708.2	9.0	68	wnw.	11.2	2,215	573.9	− 5.9	96	2.9	w.	......	......
9.50 a. m.	708.2	9.1	68	wnw.	9.8	1,495	628.4	− 1.9	100	4.2	w.	......	......
10.13 a. m.	708.1	9.1	68	wnw.	14.3	938	673.4	3.7	70	4.3	w.	21.8	......
10.21 a. m.	708.1	9.5	66	w.	12.1	526	708.1	9.5	66	6.0	w.	12.1	......
Second flight—													
11.06 a. m.	707.8	10.4	60	w.	15.6	526	707.8	10.4	60	5.7	w.	15.6	......
11.18 a. m.	707.8	10.4	57	w.	17.0	1,044	664.7	5.2	73	5.0	w.	24.5	......
11.29 a. m.	707.8	10.2	59	w.	16.1	1,757	608.5	− 2.2	94	3.8	w.	......	......
11.38 a. m.	707.8	10.2	59	w.	17.9	2,098	582.8	− 4.3	100	3.4	wnw.	......	......
12.19 p. m.	707.8	9.6	64	w.	16.1	526	707.8	9.6	64	5.8	w.	16.1	......
May 7, 1914:													
8.17 a. m.	714.0	12.8	77	nw.	13.9	526	714.0	12.8	77	8.6	nw.	13.9	......
8.25 a. m.	714.0	13.4	76	nw.	14.8	1,005	674.2	7.5	67	5.3	nw.	19.2	......
8.44 a. m.	714.0	13.6	70	nw.	17.9	1,502	635.1	10.6	25	2.4	nw.	20.4	......
9.12 a. m.	714.3	13.0	55	nw.	14.8	1,926	603.7	8.6	14	1.2	nw.	10.8	......
9.32 a. m.	714.7	13.1	57	nw.	13.4	2,429	568.2	3.5	9	0.6	nw.	10.8	......
9.44 a. m.	714.9	13.2	59	nw.	12.1	2,585	557.0	1.6	5	0.3	nw.	13.2	......
10.09 a. m.	715.1	13.6	60	nw.	8.9	2,154	587.1	4.6	5	0.3	nw.	8.6	......
10.25 a. m.	715.0	15.0	52	nw.	8.9	1,478	637.2	8.2	5	0.4	nw.	18.2	......
10.31 a. m.	714.9	15.0	51	nw.	8.5	1,353	647.0	4.2	17	1.1	nw.	16.4	......
10.40 a. m.	714.8	15.0	51	nw.	6.7	725	698.2	9.4	49	4.4	nw.	9.6	......
10.45 a. m.	714.8	15.1	52	nw.	7.6	526	714.8	15.1	52	6.7	nw.	7.6	......

April 2, 1914.—First flight: Two kites were used; lifting surface, 12.6 sq. m. Wire out, 4,100 m.; at maximum altitude, 3,400 m.

There were 10/10 St.-Cu. from the west. The head kite entered the St.-Cu., altitude 1,500 m., at about 8.53 a. m.; time of emerging unknown.

At 8 a. m. low pressure (741 mm.) was central off the southern New Brunswick coast. High pressure (775 mm.), central over eastern Alberta, covered the Missouri valley.

Second flight: Three kites were used; lifting surface, 15.9 sq. m. Wire out, 4,350 m.; at maximum altitude, 3,000 m.

There were 10/10 St.-Cu. from the west. The head kite entered the clouds, altitude 1,800 m., at 11.29 a. m.

May 7, 1914.—Four kites were used; lifting surface, 22.3 sq. m. Wire out, 4,100 m., at maximum altitude.

Before 10 a. m. there were 8/10 A.-St. from the northwest; thereafter, 4/10 Ci.-St. and 4/10 A.-St. from the northwest. A solar halo was observed at 10.15 a. m.

High pressure (764 mm.) was central over Ohio and low pressure (758 mm.) was central over Wisconsin.

14. GENERAL INDEX.

BULLETIN OF THE MOUNT WEATHER OBSERVATORY, VOLUMES 1 TO 6.

DISCONTINUANCE OF THE BULLETIN.

This Bulletin of the Mount Weather Observatory ends with part 5 of volume 6. By order of the Secretary of Agriculture it will be merged with the Monthly Weather Review and its supplements.

The research work of Mount Weather Observatory will be continued after July 1, 1914, at other points more favorably located for studying the circulation of the atmosphere over the United States.

CORRIGENDA, BULLETIN OF MOUNT WEATHER OBSERVATORY, VOLS. 1 TO 6.

Volume 1, 1908:

[No important errors discovered.]

Volume 2, 1909:

Page 42, table, column 1, under Aug. 17, 1908, for "a. m." read "p. m."

Page 48, table, column 1, under Sept. 8, 1908, for "p. m." read "a. m."

Pages 55–56, omit the six lines at bottom of page 55 and the first seven lines of page 56, and substitute: "Of propagation of the beam and parallel to the plane of vibration of the ray scattered. Suppose the vibrations in a ray propagated in the direction of *IO* to be parallel to *OP;* the scattering will be symmetrical about *OP* as an axis, being zero in the direction of *OP*, and reaching a maximum 90° from it. Similarly, any other ray propagated in the direction *IO* will be scattered symmetrically about an axis perpendicular to *IO* and parallel to its path of vibration. The vibrations of any one of these scattered rays will be in a plane containing the corresponding axis of symmetry and the ray itself. But since in a beam of unpolarized light the vibrations occur in all planes that pass through the direction of propagation, there will in this case result a symmetrical scattering about *IO* as an axis, with complete polarization in the plane *APB*, diminishing to zero polarization 90° from this plane."

Page 302, line 9 from bottom, for "statistical" read "statical."

Volume 3, 1910:

Page 229, first paragraph, line 2, for "Wein-Planck" read "Wien-Planck."

Page 234, line 5, for "166 kilometers" read "96 kilometers."

Volume 4, 1911:

Page 61, for "Fig. 22 at 1,000" read "Fig. 24 at 3,000"; for "Fig. 21 at 526" read "Fig. 23 at 2,000."

Page 62, for "Fig. 23 at 2,000" read "Fig. 21 at 526"; for "Fig. 24 at 3,000" read "Fig. 22 at 1,000."

Page 125, between the lines "Sept. 30, 1908," and "Nov. 7, 1901," insert the caption "Fall (October and November) Manned Balloons."

Page 136, line 18, for $aR=KT^m$ read $aR=KT_2^m$.

Page 275, Fig. 4 should be turned clockwise through 90°.

Page 277, Fig. 6 should be turned anticlockwise through 90°.

Volume 5, 1912:

Page 98, line 18, for "in *C. G. S.* units" read "in horsepowers";
line 36, for "the total thickness of the current" read "the total height of . . ."

Page 129, line 19, omit the "?".

Volume 6, 1913:

Pages 36, 37, for "Trappe" read "Trapp."

Page 66, make line 7 from bottom of page read: "and then helioc. long. of the point= geoc. long. of the sun, $\pm\angle$MSP, the upper sign applying"

Page 100, figure 71 should be inverted.

Page 194, in figure 33, marginal columns should be headed "Temp. °C."

CONTENTS.

NOTE.—Those who can spare any volumes or parts of this bulletin are respectfully requested to inform the Chief of the Weather Bureau.